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GENERAL DATA PROTECTION REGULATION: IMPACT AND IMPLICATIONS ON MOBILE OPERATORS

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Abstract: *The EU General Data Protection Regulation significantly expands the rights of the individuals related to the data privacy. At the same time, it defines the new obligations and responsibilities of the companies collecting and processing personal data. The goal of this paper is to provide the analysis of the new regulation in the context of mobile operators' business. It summarizes the main challenges and identifies the main steps for the practical implementation of the compliance. Finally, it emphasizes the potential for the different business benefits if the compliance to the new regulation is implemented in a correct way.*

Keywords*: GDPR, mobile operators, personal data, data privacy*

1. INTRODUCTION

Expansion of the digital services which has been happening last years in the different industries has led to the enormous amount of the data related to the users of those services, their habits, preferences, health, financial status, spending patterns and other personal information. For the digital services providers this set of data represents a potential for the highly personalized offering and consequently for a new business/new revenue. Furthermore, personal data became a tradeable asset in the digital economy ("new oil of Internet") and this emerging market of personal information raised a large number of economic, technical, social and ethical issues with particular concerns about privacy (Spiekermann, Acquisti, Böhme, & Hui, 2015).

After 4 years of debate, in April 2016, EU Parliament finally approved new General Data Protection Regulation. The EU General Data Protection Regulation (GDPR) replaces the Data Protection Directive 95/46/EC and was designed to harmonize data privacy laws across Europe, to protect and empower all EU citizens data privacy and to reshape the way organizations across the region approach data privacy ("Home Page of EU GDPR," n.d.). Enforcement date of the new regulation is 25th of May 2018. The GDPR expands the scope of data protection and the definition of personal data and every organization that collects and processes the data related to EU citizens must comply with it, no matter where they are based or where the data is stored.

This implies that organizations should adopt different internal measures that meet the principles of data protection by design and default (Tankard, 2016). Besides the technical/technological and organizational changes that are required, regulation related to the handling of personal data has its economic value and consequences (Acquisti, Taylor, & Wagman, 2016).

In the first part this paper provides a brief overview of the EU General Data Protection Regulation, reactions, and consequences that it has provoked and then focus particularly on the impact and implications that the GDPR has on mobile operators and their current and future business.

2. LEGAL FRAMEWORK

GDPR is intended to be a strong and coherent data protection framework in the EU, backed by strong enforcement, given the importance of creating the trust that will allow the digital economy to develop ("Regulation (EU) 2016/679 of the Euripean Parliament and of the Council,"n.d). Main actors which rights and obligations are defined by the regulation are the following:

- **Data Subjects** – Natural persons to whom apply the protection afforded by GDPR, in relation to the processing of their personal data
- **Data Controller** - A natural or legal person, public authority, agency, or other body which, alone or jointly with others, determines the purposes and means of the processing of personal data
- **Data Processor** - A natural or legal person, public authority, agency or other body which processes personal data on behalf of the controller ("Regulation (EU) 2016/679 of the Euripean Parliament and of the Council,"n.d).

The GDPR is applicable to:

- the processing of personal data by controllers and processors in the EU, regardless of whether the processing itself takes place in the EU or not
- the processing of personal data or monitoring of behaviour of data subjects in the EU regardless of whether as controller or processor is established in the EU or not.

Key principles and key changes comparing to the previous legislations addressing this matter are summarized in the rest of this chapter.

2.1. Rights of Data Subjects

In order to protect individuals and their personal data, GDPR defines the following ("Regulation (EU) 2016/679 of the Euripean Parliament and of the Council,"n.d):

Transparency and easier access to data (Right to access): Individuals must be allowed to get in an easy way the clear and understandable information on how their data is processed. This means that data subjects have the right to know which personal data concerning them is being collected and processed, where and for what purpose including the information about third parties to whom this data has been or will be disclosed. Furthermore, if requested, the controller shall provide a copy of the relevant personal data collected about the data subject, free of charge, in an electronic format. Controller may only charge for such a request in excessive cases.

Consent (Right to choose): Explicit consent of data subject's is required before processing of the sensitive data. Request for consent must contain the explanation of the purpose for data processing. Consent must be revocable and both giving and withdrawing the consent should be the data subject in an easy way. When the data subject is minor, parental approval is mandatory. The controller must be able to prove that the contest has been given.

Right to object: Data subject has the right to object to processing of his/her personal data on certain grounds, in addition to the right to object to processing for the purposes of profiling or direct marketing.

Right to change/rectify: Data subject has the right to update incomplete/incorrect details

Right to be forgotten: If an individual wants her/his data to be deleted, and if there is no legitimate basis for retaining and further processing it, the data must be erased.

Right to data portability: Individuals must be able to easily transfer the data between the different service providers (data processors/controllers).

Rights to be notified and compensated: Individuals must be notified in case of data breach which may have serious impact on them and have the right to be compensated for material and immaterial damages caused by non-compliant processing.

2.2. Accountability and obligations of the Data Processors and Data Controllers

While protecting and expanding the rights of the Data Subjects and increasing the level of control they have over their personal data, the new regulation is at the same time introducing direct obligations for the service providers in the role of data processors/data controllers, making them accountable for the GDPR-compliant way of working.

They have to implement appropriate technical and organizational measures to ensure that their products, services and internal business processes are designed following the data-protection principles (**Data protection by design)** and that by default, only personal data which are necessary for each specific purpose of the processing are collected, stored and processed (**Data protection by default)** ("Regulation (EU) 2016/679 of the Euripean Parliament and of the Council,"n.d).

Where a type of processing is likely to result in a high risk to the rights of data subjects (e.g. in case of particular new technologies or in case of automated processing which includes profiling), the controller shall, prior to the processing, carry out an assessment **(Data privacy impact assessment**) and undertake all the measures envisaged to address the risks, to ensure the protection of personal data and to demonstrate compliance to the GDPR ("Regulation (EU) 2016/679 of the Euripean Parliament and of the Council,"n.d).

Data processors/controllers are further obliged to maintain the records of all processing activities under their responsibility, to cooperate with supervisory authority and if a personal data breach occurs, to notify the

supervisory authority, not later than 72 hours after having become aware of it ("Regulation (EU) 2016/679 of the Euripean Parliament and of the Council,"n.d).

GDPR increases the power of the supervisory authority (regulator) and defines different corrective actions including penalties that regulator can apply towards data processors/controllers in case of non-compliance to the regulation. For serious infringements, a fine can go up to 20,000,000 EUR or up to 4% of the annual worldwide turnover of the preceding financial year, whichever is greater.

2.3. Reactions and interpretations

From one point of view, the GDPR is seen as the regulation that encourages digital transformation and represents a demand for effective data management practices and a holistic overview of all data held within a company which will enable a proactive cyber-security (Zerlang, 2017). From the others, some concepts are considered as already obsolete, inadequate, or controversial.

Concept that has been particularly commented is Data Protection/Privacy by Design. Two main remarks can be summarized as the following: it presents too abstract a framework to inform design; and it is often applied too late, i.e. after many critical design decisions have been already made in defining the business opportunity (Edwards, McAuley, & Diver, 2016).

Recommendations for the improvement goes from promoting a deeper understanding (R&D community, education, media, policy makers) and including privacy considerations in the standardisation process (Danezis et al., 2015) to the proposals to transform Privacy by Design approach to much wider Social Impact Assessment methodology with practical guidance to be applied at product/service concept stage as well as throughout the system's engineering (Edwards et al., 2016).

Conclusion that is common and indisputable is that the GDPR will force businesses to restore order to their operations and while it will deliver restrictions, it will also provide many benefits to businesses (Krystlik, 2017). In the process of achieving compliance, organisations will face many challenges, but at the same time many opportunities (Mansfield-Devine, 2016).

Remaining part of this paper analyse those challenges and opportunities in the case of mobile operator. (N.B. This analysis is limited to the data subjects using services of mobile operator and the protection of their privacy, not to the employees in the role of data subjects).

3. MOBILE OPERATORS AND PERSONAL DATA

Mobile network operator is a service provider of telecommunication services over wireless (mobile) network. In addition to the core telecommunication services as voice and data traffic, mobile operators are quite often including in their offer partner services (e.g. mobile payment of parking services).

Being in data controller/data processor role, mobile operator is collecting and processing huge amount of the data that according to the GDPR are considered as personal information. Besides two main identifiers, International Mobile Subscriber Identity (IMSI) and Mobile Subscriber ISDN Number (MSISDN), mobile users are associated with several others as name, physical address, personal ID, name of the company (in case of business users), etc. There are some other demographic data (age, gender...) that can be left voluntarily during the registration or interaction with the customer care, however most of personally identifiable information related to subscribers is collected or generated while providing the services.

One of the main relationships between the mobile operator and the end-user is billing relationship regardless the user's choice to pay before (prepaid) or after using the services (post-paid). Charging and billing data generated by corresponding network elements are very extensive and include different information about the call/message/data session as the time stamp, location and the mobile device used by end-user, called number, or visited site, streamed/downloaded content etc. In case of roaming there is an info about visited network, and consequently about the country visited by the end-user (data subject). To get better/cheaper rate plans, users often opt in for the packages which require explicit definition of the "favourite numbers", i.e. family, friends, community. Significant volume of the personal data can be generated during network monitoring activities or for statistical/analytical purposes.

Extensive set of collected data is mainly used for internal purposes: charging, billing, reporting, customer segmentation, campaign management, personalized offering, customer experience management, etc or unused at all. Disclosing of personal data to third parties might occur only in limited number of predefined

cases related to the legal obligations (e.g. lawful interception or emergency positioning) or in cases where subscriber has allowed/approved this either by opting in for partner services (e.g. mobile advertising) or by defining other subscriber(s) who can get a subset of his/her personal data (e.g. location).

During last years, users have become suspicious of the organizations that collect, store, and use their data. The primary concern of consumers is that organizations might sell their personal data to third parties without their consent. Decrease of trust happened in all segments, but it is much lower in communication services providers than in case of social media companies or digital disrupters (e.g. Uber). In emerging markets, communication services providers are still the most trusted organisations by consumers for handling personal data while in mature markets they are second to bank/credit cards companies (van den Dam, 2017).

3.1. GDPR compliance in case of mobile operators

The implementation of the GDPR indicates the need for various actions, planning, the assignment of new responsibilities and the acquisition of new expertise. The twelve aspects identified as the practical implications of the GDPR changes with the most relevance to all personal data intensive companies are summarized below (Tikkinen-Piri, Rohunen, & Markkula, 2017):

1. Specifying data needs and usage
2. Considering conditions for data processing in international context
3. Building privacy through data protection by design and default
4. Demonstrating compliance with GDPR requirements
5. Developing processes to deal with data breaches
6. Reckoning with sanctions for non-compliance
7. Designating a DPO (Data protection officer)
8. Providing information to data subjects
9. Obtaining consent on personal data usage
10. Ensuring individuals' right to be forgotten
11. Ensuring individuals' right to data portability
12. Maintaining documentation (Tikkinen-Piri et al., 2017).

Although mobile operators already follow much strict legislation than most of the other companies handling personal data, compliance to GDPR still imposes numerous challenges to them, mainly due to the number of systems manipulating subscribers' data and the diversity and complexity of the relations they have with the subscribers. Practical aspects of GDPR implementation specified above are hereafter analysed in the specific technical and business environment of the mobile operators and grouped within four action streams as outlined in the table below and explained in the following subchapters.

Table 1: GDPR implementation in case of mobile operators

Action Stream	Practical Aspects of GDPR implementation
New competence and new resources allocation	Designating a DPO, Developing processes to deal with data breach Reckoning with sanctions for non-compliance
Inventory of subscribers' personal data and subscribers' personal data handling processes	Specifying data needs and usage Demonstrating compliance with GDPR requirements Ensuring individuals' right to be forgotten Ensuring individuals' right to data portability Maintaining documentation
User interface and Consent management	Providing information to data subjects Obtaining consent on personal data usage Ensuring individuals' right to be forgotten Ensuring individuals' right to data portability Building privacy through data protection by design and default
Suppliers and partners management	Building privacy through data protection by design and default Considering conditions for data processing in international context

3.2. New competence and new resources allocation

First step in implementing GDPR compliance is to build and/or acquire the competence related to this matter. This is a prerequisite for performing data privacy impact assessment, the analysis of the gap between the current and GDPR-compliant implementation and to define new processes and procedures.

Procedures related to the possible data breaches must be defined, as the mobile operators have the obligation to notify regulators and the affected individuals (data subjects) about data breaches as early as

possible. All of this require a dedicated team responsible for defining data protection strategy and implementing measures and activities needed to ensure compliance with GDPR. A formal leading role for all data protection activities is the Data Protection Officer (DPO).

Besides the human resources, mobile operators must plan and allocate significant financial resources for the practical implementation of the GDPR and to calculate the financial risk exposure in case of non-compliance.

3.3. Inventory of subscribers' personal data and subscribers' personal data handling processes

In many of the current implementations, subscribers' personal data are collected, handled, and kept in separate silos (core network department, CRM/customer care, billing) without complete alignment between them, despite the existence of the centralized data warehouse system.

To be able to demonstrate GDPR compliance, operator must be able to prove that the subscribers' personal data are correctly handled, to verify that the processing flows are auditable at any time and to prevent loss of personal data, or loss of track of those personal data ("Enabling GDPR Compliance for Operators - TM Forum Project Charters Space - TM Forum Confluence," n.d.). To achieve this, operator must:

- identify the different platform and processes within those platforms which manipulate personal data
- identify the parties engaged into the processes
- identify the flows and directions
- identify the processes of each party
- define tools & processes to constantly keep updated those information for each platform ("Enabling GDPR Compliance for Operators - TM Forum Project Charters Space - TM Forum Confluence," n.d.).

Following the requirement for data minimisation, mobile operator must review and re-evaluate their current policies for the collection, generation, storage, processing, deletion, and disclosure to the third parties of the subscribers' personal data, to categorize the data that is collected and processed and to decide what is really needed for the business operations and for the lawful purposes. Personal data for which neither business nor legal justification cannot be found must be deleted. Important part of this process is to define the access policy to all the personally identifiable information/data that will remain and to separate the data set that is kept for legal purposes only in order to avoid that this information is accidentally processed in some other scenarios.

Making review and inventory of the subscribers' personal data, should also include review of the consents received so far. The way of performing customer segmentation or preparing personalized offering and targeting subscribers with them, should be revised in the context of GDPR clauses related to the profiling of data subjects.

Data model in this personal data inventory must be user-centric to secure that individuals' right to get a copy of his/her data or right to be forgotten and right to data portability can be satisfied in a correct and efficient way. Data model must include relationships between minors and parents/guardians.

3.4. User interface and consent management

Strict requirements related to the rights of individuals (data subjects) combined with variety of services from mobile operators' portfolio make the area of user interface and consent management the most demanding for the implementation of GDPR compliance.

The solution outlined by the global industry association (TM Forum) suggests the introduction of the Privacy Control Point which will provide ("Enabling GDPR Compliance for Operators - TM Forum Project Charters Space - TM Forum Confluence," n.d.)

User presentation - A central GDPR dashboard to support data transparency and clear and easy presentation of the personal data to the end user and interfaces to support inclusion of a dashboard in the existing (or new) omni-channel solution for the end-users' interaction.

Privacy and consent management – Individual user could have many services, including those that are not provided solely by the operator (i.e. partners' services). Consent requested and collected from the end-user must be at the individual service level and aligned with the user and service lifecycle.

Logging of all privacy related operations

API Access – controlled access to and exposure of subscribers personal data (including consents) either internally, i.e. within the operator's domain or externally, from/to partners domain ("Enabling GDPR Compliance for Operators - TM Forum Project Charters Space - TM Forum Confluence," n.d.).

Such an approach assumes the logical architecture based on "traditional" concepts, as APIs. Representative example is TMF644 Privacy management API which provides standardized mechanism for privacy profile types, privacy profiles and privacy agreements such as creation, update, retrieval, deletion and notification of events ("TMF644 Privacy Management API REST Specification R16.0.1 - TM Forum," n.d.).

The most challenging aspect of the scenario described above is to secure the data transparency and the right to withdraw the consent and/or erase the personal data in case of partner services. In the absence of a central logging facility that acts as a trusted third party, it can be extremely difficult to trace which partner organisations have accessed individual data sets (e.g. if partner further disclosed the data to another partner/3rd party) and to provide relevant information/response to an individual who requests information or action on his/her data.

Potential answer to this demand are solutions based on the latest file-distribution, blockchain and encryption technologies. In a purely decentralised peer-to-peer environment of equal partners, without requiring any centralised instance or further authorisation steps, the provider of data is empowered to trace the access to the data by partners in the distributed and shared data pool. This trace of access is without any doubt and cannot be denied (Roth, 2017).

Application of the blockchain technology in mobile network is still in a very early stage or "proof-of-concept" phase. To apply it in the live network and on commercially available services would be a crucial change and this would require close cooperation of the main industry players and regulators. However, the number of use cases in which mobile operator could benefit from the blockchain technology is constantly increasing (5G service enablement, IoT), thus this change might happen in the near future and the blockchain might become a long-term solution for the privacy and consent management.

3.5. Suppliers and partners management

Mobile operator is the primary contact point for the subscriber and from GDPR perspective accountable for proper handling of subscriber's personal data. However, the ecosystem in which mobile operator does the business, inevitably include different entities as suppliers and partners. There are different technical barriers which prevent operator to have the full control on how the subscribers' personal data are handled in the whole ecosystem (example given in the chapter 3.4), but from the legal perspective, operator can and should include GDPR related clauses and liabilities in all the agreements with the partners and suppliers.

Following the obligation for data protection by design and default, operators should include corresponding technical requirements in all requests for purchasing new equipment to ensure that the tools and support for privacy protection will be provided as a part of standard functionalities and not as customer specific adaptations/product customizations. This is especially valid for the new Business Support Systems (solutions that support customer-facing activities as billing, order management, customer relationship management, etc…) and Operations Support Systems (solutions that support back-office activities as operation of mobile network, provisioning and maintaining of customer services). Vendors/suppliers should have privacy impact assessment built into their product development lifecycle and should advise operators about the privacy impact of new technologies.

GDPR conditions for personal data transfers to a third country or an international organisation should be carefully evaluated in cases when companies acting as the providers of technical support or managed services to mobile operator, have their global service centres abroad. Before allowing export of any subscriber database or its part, that might be required as a part of operation and maintenance or troubleshooting processes, anonymisation or pseudonymisation of subscribers' personal data must be secured. (Pseudonymisation is the new concept introduced in GDPR, which refers to personal data processing in a way that the data cannot be attributed to a specific data subject without additional information ("Regulation (EU) 2016/679 of the Euripean Parliament and of the Council,"n.d).)

4. DISCUSSION

The EU General Data Protection Regulation demand from mobile operators to implement numerous technical, organizational, and procedural changes, to aquire new skills and to make significant financial investment. Still, it should be considered as a business opportunity, rather than a new obligation or a problem. If the GDPR related challenges are addressed by mobile operators in a proper way, this could bring them important business benefits summarized in the table below.

Table 2: Potential benefits of the GDPR implementation in case of mobile operators

Results of GDPR implementation (internal perspective)	**Potential business benefits**
Common user-centric data model	To simplify reporting and other business processes To reduce the risk of revenue leakage caused by misalignement between different subscriber databases
Removal of unnecessary data and of redundant data processing flows	To decrease operational costs
Clean inventory of subscribers' personal data Clear policies and procedures for handling subscriber data	To improve operational efficiency
Results of GDPR implementation (external perspective)	**Potential business benefits**
Demonstration of the GDPR compliance	To further strengthen the brend To improve customer satisfaction and loyalty To reduce churn and/or acquire new subscribers from the competitors To monetize the trust by developing and offering new digital services

4.1. Monetization of trust and new business opportunities

In the current circumstances, mobile operators worldwide are experiencing a decline in revenue from traditional services (voice and SMS) due to the increased usage of the communication services provided by OTT (Over-the-top) players like Skype, Viber, WhatsApp…By positioning themselves as the trusted communication services provider, mobile operators can justify the price of their services and further develop new digital business opportunities, including those in which they will offer to partners to leverage on their privacy protection infrastructure (e.g. privacy control point and corresponding API).

At the same time, telecommunications industry is preparing for the fifth generation (5G) of wireless technology which will significantly increase the speed and coverage and reduce the latency in mobile network. 5G is expected to play important role in the digitalization of the different industries, as manufacturing, automotive, agriculture, energy and utilities, public safety, healthcare, public transport, media, and entertainment etc. Evolution of mobile operator from the traditional provider of telco services to the digital enabler means that significant growth of IoT connections is expected, both in consumer and industrial segments. This opens the potential for the new revenue streams and at the same time, much broader concerns about privacy then in case of traditional telco services.

For the user centric and data centric 5G use cases to be accepted and to function as a viable business model, user trust in their data privacy is paramount (Khajuria & Skouby, 2017). As the protection of personal data will be very relevant for 5G adoption, all the efforts and investments that mobile operators make to achieve GDPR compliance could help them to monetize future 5G-enabled business opportunities.

5. CONCLUSION

This paper presents an overview of the new EU regulation related to the protection of personal data, with focus on implications it is going to have on the mobile operators and their business. It identifies the main steps to be done and even provides some ideas for implementation. Thus, it can be considered as a sort of guideline for the providers of telecommunications services who want to achieve GDPR compliance. Highlighted is the fact that the GDPR, if properly implemented, could bring several benefits to the mobile operators, and open the possibilities for improving their operations and capturing new revenue streams.

Possible future research associated to this topic can address the end-user expectations and concerns in terms of privacy in the 5G-enabled use cases and propose the way on how the mobile operators can respond to them sucessfuly.

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TELECOM CRM EVOLUTION IN THE DIGITAL AGE

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Abstract: *Telecommunication companies have great pressure for very fast adaption to new market conditions and new technologies in order to satisfy customers. Since customer became center of the telecom world, the topic processed in this paper is telecom customer relationship management in the digital era, challenges and possible solutions. This article shows analysis of market trends and common implementation of CRM systems in telecom companies and it gives an overview of key pain points in standard solutions. The purpose of the paper is to suggest a way for improvement CRM processes trough considering appropriate system architecture plan.*

Keywords*: customer relationship management, CRM, digital CRM, digital, telecommunication*

1. INTRODUCTION

Nowadays, telecommunication companies are part of an industry which grows very fast. Especially in the domain of mobile services where new technologies and products are changing the way of business, a way of communication, a way of living at all.

It is very clear by hart that there is more and more population using mobile phones and, in addition to that, statistics tell the same – at the end of 2017, there were around 5 billion mobile subscribers worldwide according to GSMA, with more than 50% subscribers using the mobile broadband network (3G/4G). Mobile data traffic, as the most important thing, today is based on broadband with really high speed. Even that will be changed soon by introducing 5G network. It has been expected that 5G will be commercially live in next few years and it will bring a situation where latency will be minimal or it will no be latency at all (for example, the surgeon would be able to run robotic glove in order to perform surgery on distance).

Telecommunication companies are in the middle of this storm and there is a big question for them: should this kind of company gives only connectivity to users and other companies or they can do something more. Everyone develops new strategies to take advantage of new potential customers and to have more than good customer retention program. Companies need to put a lot of effort on customer relationship management as a process, but also very important is to take care to have CRM tool which can fulfill all needs.

The goal of this paper is to analyze Serbian telecommunication market and to suggest a way for improvement CRM processes trough considering appropriate architecture. The more specific goal is to point out on weaknesses of common implementations of CRM tools and how new technologies can help.

2. CUSTOMER RELATIONSHIP MANAGEMENT

Customer relationship management (CRM) is an IT tool which allows the company to gather and analyze information about customers such as previous sales, answered and not answered calls to customer center, solved and not solved problems, active products and services (Nguyen, Sherif, & Newby, 2007). Collecting all this information has a purpose to keep the customer satisfied with current operator trough two simple steps (Ferdous & Rahaman, 2009):

- To use pattern and trends in order to offer the right product to the customer
- To create churn and behavioral prediction model

Facts which are listed in this paper point out that care about existing customers is the most important thing today. With proper care about existing customer, first of all, they will stay loyal to the operator and at the end will bring the revenue. The second one, through the word-of-mouth customers will recommend their operator to others. Living in the age of the Internet, word-of-mouth should not be neglected since all situations, good and bad, are spread through the network in seconds (Eunjin & Byungtae, 2005).

Revolution in IT brought us CRM tools where it is easy to define profitable and non-profitable subscribers, but not with the idea to let go non-profitable ones. Nowadays, customer retention programs are number one priority for mobile operators. CRM process and CRM tool should be modeled with special attention on a fact that today is social media age. Currently, technologies which make the difference in CRM are social media, especially social media free tools (Harrigan & Miles, 2014). A new way of CRM, digital CRM or e-CRM has a positive impact on customer loyalty which was researched by (Azila & Noor, 2011).

In probably all areas of industry, the center was moved from marketing and similar things to customer. The customer now is in the middle of all happenings. Empowering customers and putting them in the center has brought new challenges for customer relationship management (Lipiäinen, 2015).

Next chapters show detailed architecture common in the telecommunication industry, which reveals main pain points.

2.1. Traditional CRM

In telecommunication companies, there is one main split between systems: OSS and BSS. OSS or Operational Supporting Systems represents a group of systems and software that are used for managing firstly core network side, network infrastructure. On the other hand, BSS or Business Support Systems is a group of more IT systems with a role to support business processes and systems dealing with the customer directly. CRM tool usually belongs to Business System Support (BSS) stack. In BSS stack should count systems responsible for billing and charging, customer care, sales support, order fulfillment, dependent on implementation.

Till a few years ago in the industry of communication, it was considered that architecture should be billing centric. And it is true that for the majority of customers, things like rating, charging, invoicing was on the top of the list of priorities.

Traditional CRM in the past was a system which has only basic information about the customer and it was used as a kind of support to billing systems. There was no much attention to put information in one place and in a structured way, so agents on the first line can cope with every situation.

The following figure shows the very simplified architecture of BSS stack and role of CRM in it like it was common in last decade. Simplification in this view is necessary in order to focus on a problem pointed out in this paper.

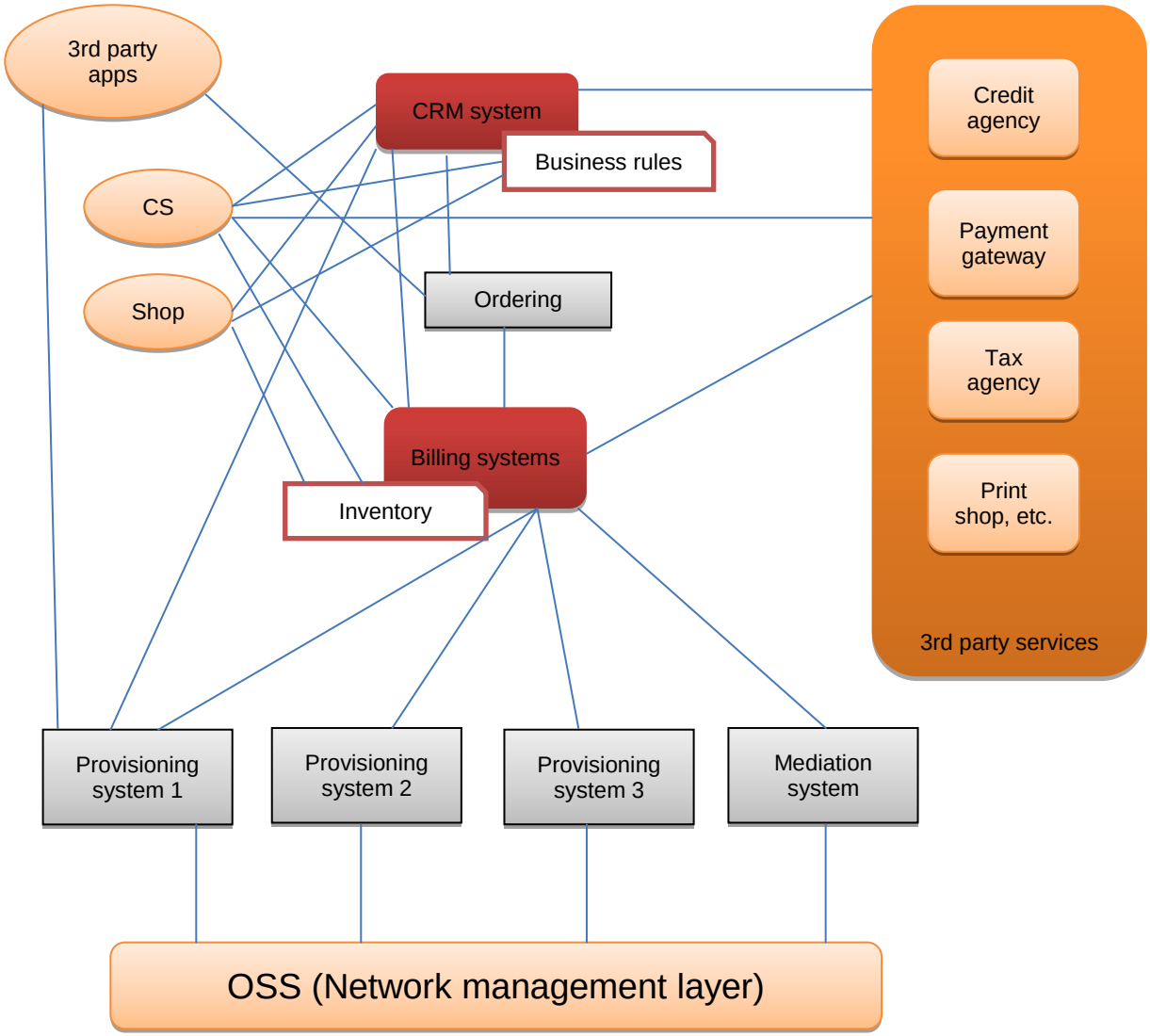

Figure 1: Presentation of simplified common traditional BSS architecture in TelCo

This kind of implementation was good in past years since customer need was to come to shop or call customer service and get information or activate services. But already some time this architecture is completely unsustainable since, firstly, there are more channels for interaction with the customer. Customer needs are higher but this set up is bad for few general reasons:

- High costs for maintaining
- No clear definition of which functionality belongs where
- Integration was done per case trough time which led to, so-called, spaghetti architecture
- Silo architecture is present meaning that each system functions for itself
- Processes are not and cannot be automated which means high manpower costs
- Double work is highly present, as well as duplication of systems, functionalities, and data
- Time to market is very low
- Bad customer experience and customer service

Also, there are more specific reasons why this architecture is not usable anymore. For example:

- Inventory is on billing system as the central point. That causes that billing systems need to be very responsive and scaled for a huge number of calls from external systems, like CRM
- Inventory can be synchronized back to CRM in order to lower pressure on the billing system, but in that case, there is no real-time information about customer actions or customer state at all
- Bad information modeling is present since each system has own database with same data but in a different form

The situation in a big and complex company, such are companies in the telecom industry, became that it is easier to drop off the whole stack of systems and build completely new ones. The idea of upgrading and adding new functionalities is a nightmare. Every new functionality, even a small change in one system

usually means changes on surrounding systems, too. But systems cost millions and there is no that company that can afford often replacement of these systems.

2.2. Digital CRM

The term “digital CRM” is actually a concept which is incorrectly formulated. There is no such thing as digital CRM. Everything is digital in modern systems. By this term, usually, it is considered content in digital form and a way of communication with customers and other stakeholders. CRM could be considered as a tool for the process of digitizing all gathered information about the customer (Nguyen et al., 2007). The majority of information today is on social networks. Successful social CRM implies that traditional CRM should be upgraded and extended in a way to cover social networks (Harrigan, Soutar, Choudhury, & Lowe, 2015).

The main goal for existing telecommunication companies should be to put the customer in the center and to adopt customer care in a way where all parts would be satisfied – company, employees and customers.

The worldwide market situation has been changed on several fronts:

- A new technology appears almost every day. Those technologies can help in daily business but it is not always true. In order to be competitive and innovative, companies need to afford themselves to put human resources in research and development of prototypes. Not every new thing is good, neither applicable to the business of the company.
- Customers want something more, something new. They want personalized approach and that everything can be done online and fast, for the start.
- Since the market is very saturated and there are no much more new things to offer in simple communication, companies need to figure out new revenue streams. Usually, those revenue streams are not core business, but telecommunication operators have a big advantage since they are ones who provide connectivity. This is a place where new technologies can find a place: IoT (smart homes), augmented reality, big data, machine learning. For example, a huge amount of information is collected in CRM and surrounding databases, so technology based on BigData is more than desirable to be used for creating such models which can help company itself or even be sold to a third party (statistical data, not data about the customer).
- Growing of new competitors is also an alive thing. Today MVNO (mobile virtual network operator) is a modern and profitable business without a lot of risks since it is completely virtualized. That operators don’t have to invest in the most expensive thing – infrastructure.
- As it is mentioned in this paper, mobile data usage has constant grow. Also, new network capabilities are coming pretty fast for such kind of services. So, when LTE (4G) was introduced set of completely new products appeared. Now, 5G is ready to be launched.

All above is a reason why operator needs a new way of doing BSS. Since the customer is in the center of events today, customer relationship management could also be in the center of BSS architecture in a telecommunication company. Digital CRM implies that all channels used for an interaction are connected and integrated, so CRM can have all information: basic information about the customer, billing information, geolocation, active inventory, previous sales, information about complaints through all channels, etc. (Nguyen et al., 2007)

In previous years customers used a lot of channels for interaction. As it is stated by (Padam & Sridhar Marella, 2017): “As the Internet of Things is evolving and devices go online, completely new channels add data and interactions to CRM”. The multichannel approach is necessary in order to track all customers’ activities. Actually, not just multichannel, but omnichannel. Multichannel is different from omnichannel in one, but the thing which makes a difference. Multichannel is an approach where it is considered that customer use different channels for one activity, but those channels are not aware of activities through other ones. On the other hand, omnichannel is called a situation where all channels for customer integration are highly integrated. From the perspective of customer experience, it is mandatory for a company to have integrated solution because it is the only way to prevent misusing of systems and to provide perfect customer care.

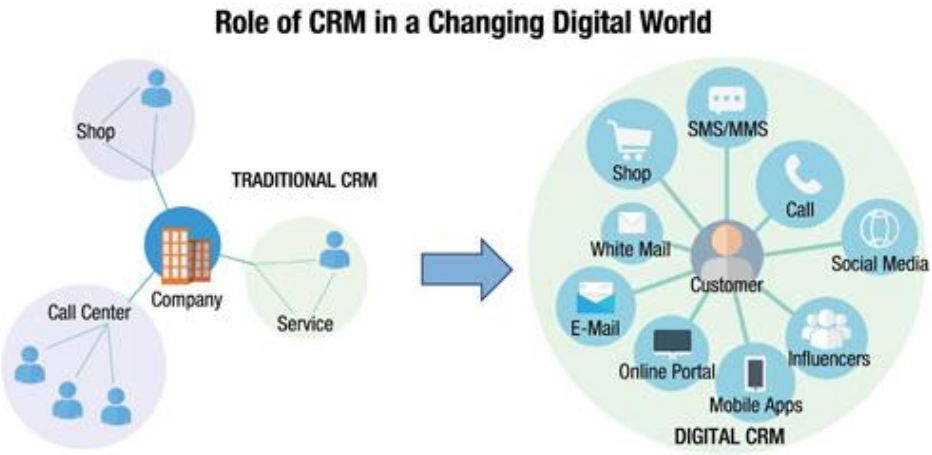

Figure 2: Role of CRM in a changing digital world (Padam & Sridhar Marella, 2017)

3. MARKET OVERVIEW

In Serbian market current situation is similar to the worlds with few deviations and market specifics. First of all, it is needed to show in which direction Serbian market goes and to recognize problems in order to be clear what kind of CRM is desired and why.

Serbian regulatory agency (RATEL) has been announced detailed report for the 2016 year. From the report few things dominate (RATEL, 2016):

- Total number of subscribers in a mobile network is on the same level in past 4 years and it's around 9.1 million
- Number of subscribers per 100 number of citizens is in stagnation but penetration is still huge: 128,52%
- Postpaid subscriber database is growing compared to prepaid
- The number of sent SMS and MMS is rapidly decreased
- Mobile data usage has constant growth
- Network coverage with LTE is better from year to year in case of all operators

Information from this report shows that Serbian market is obviously very saturated and there is no a lot of room for gaining new customers. Option for attracting new customers is only through the process of mobile number portability. So, operators need to convince the customer to give up on the previous one and to trust new operator. From the year of 2011 when MNP has been introduced in the market, a number of ported subscribers grows, which is shown on following graphs.

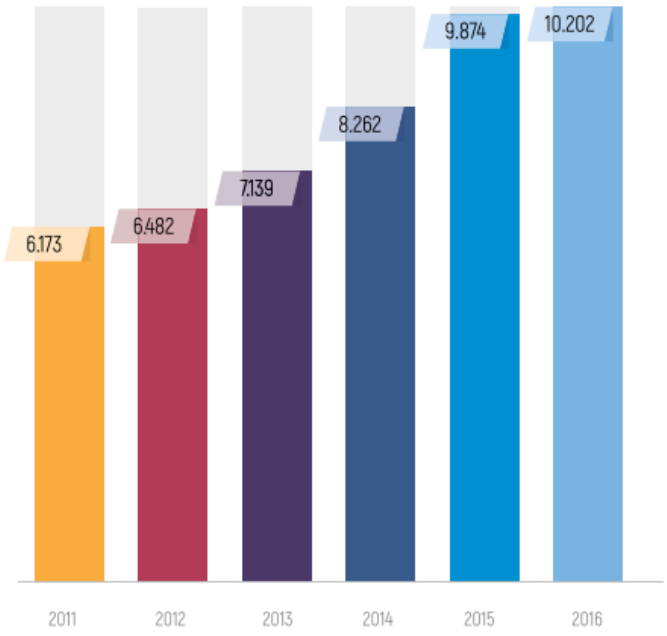

Figure 3: Average number of ported subscribers per month trough years (RATEL, 2016)

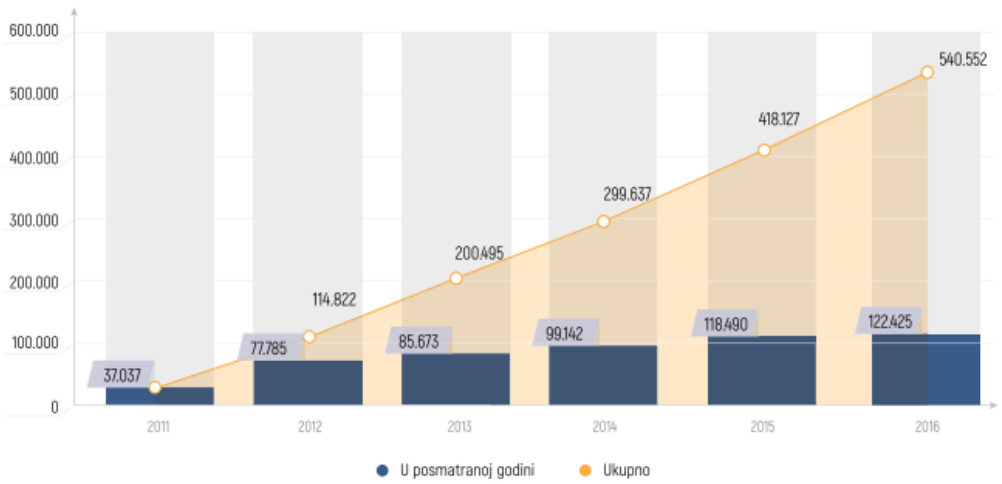

Figure 4: Ported subscribers per year and in total (RATEL, 2016)

Considering type and usage of customers that situation pretty follows modern West European markets. A number of postpaid subscribers grow compared to prepaid and finally, in the market from 2016, there is more postpaid than prepaid subscribers. Usage of voice traffic has been increasing due to the fact there are more postpaid subscriptions, but the usage of SMS and MMS is rapidly lowering. The main word in messaging part was taken over by applications based on internet usage (Viber, WhatsApp, Facebook Messenger, etc.). Today, life is unthinkable without applications which make us each day work much easier. For all of them, one thing has been in common: data usage. Figures tell how much data traffic has been increased in Serbian market:

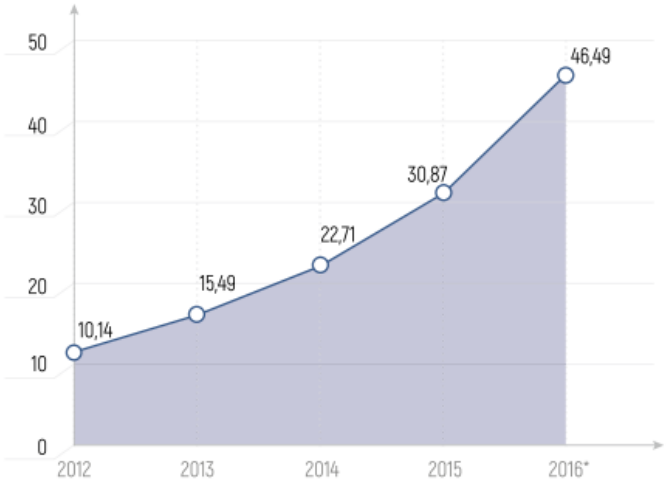

Figure 5: Amount of data transferred in million GB (GPRS+UMTS+LTE)

Those graphs and numbers show that customer care became the most important thing in contact with customers. It is very simple – in Serbian market there are no new customers. Already every third man in Serbia has two mobile numbers. The market is saturated and new customer can be reached only if he decides to leave current operator and sign the contract with new.

Need for good customer care and customer retention program puts CRM, as a process and as a tool, in the top of the list priorities in Serbia. And not just CRM, but CRM which can respond fast and with accurate data in every moment. It is crucial for communication with a customer that operator knows immediately about customer's action through any channel in order to afford appropriate support and answers to all possible questions.

The current implementation of CRM and whole BSS stack in Serbia is similar to the world's situation:

- No clear architecture design
- A lot of unnecessary interfaces causing spaghetti
- No automation of processes
- Time for launching products is too long
- No real-time data in CRM

4. PROPOSED CRM ARCHITECTURE

One of the possible architectural designs is shown in the following the figure.

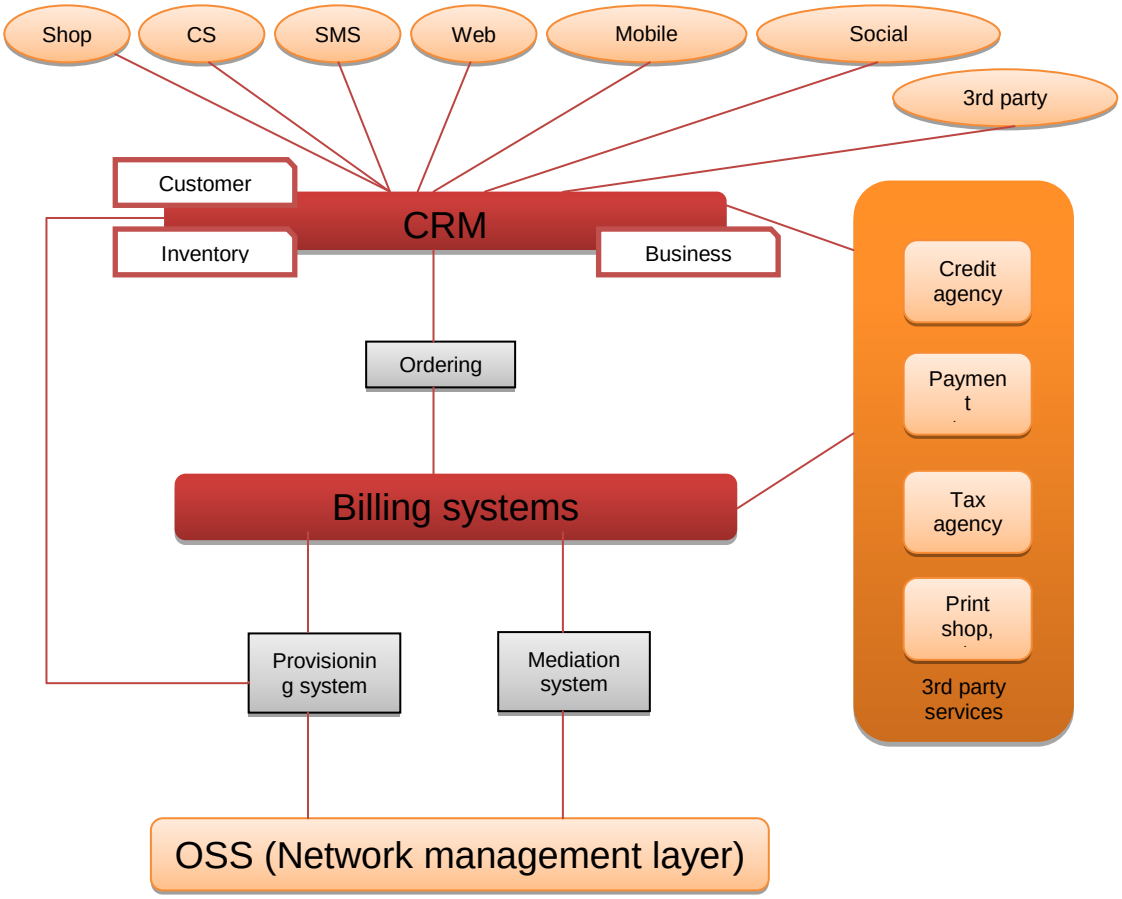

Figure 6: CRM centric architecture with omnichannel

Proposed architecture covers the most of pain points numbered in this paper. But, first of all, it is a way to answer on challenge how to cope with legacy systems. Idea is to put the right thing in a right place in order to let old BSS systems to do what they meant for. In shown case CRM is a place where all rules are implemented, CRM contains complete customer inventory and CRM is responsible for holding accurate customer data. This means that CRM is the only system which communicates with backend systems and all customer-facing systems should contact CRM in order to perform any action. No matter is it just check balance or activation of a new customer.

Good thing also is that introducing new solutions independent from the technology to BSS stack is possible and easy. That could satisfy a need for new revenue streams. If API which CRM expose is simple enough company can choose either to connect 3rd party apps or to create their own apps. Applications and channels mentioned in the previous figure are mandatory these days, but it should not be the end of story. Possibilities for creating new products with new technologies for one telecommunication operator are enormous.

The solution, of course, isn't perfect in all aspects. For this kind of implementation, it is very important to have stable and reliable CRM. Redundancy is mandatory as well as that system need to have more instances working in parallel, to be scaled in a good manner, to have great performances and very low response time. But even the most stable system sometimes goes down and no matter what backup processes need to be figured out. Backup solution by default brings disagreement in data so sync processes also need to be placed in order to support exceptions.

As it is already stated, today, in existing company, with all legacy systems, changing the way of business as proposed is not an easy job. It is very demanding to improve processes by changing systems with running a business as nothing happens. "In the online environment, the introduction and maintenance of CRM require a complex process of planning, analysis, strategy design and implementation" (Gurău, Ranchhod, & Hackney, 2003).

5. CONCLUSION

The assumption for a successful business is to have real-time communication and to manage interaction in a proper manner to all stakeholders (Despotović-Zrakić, Vasiljević, & Milinović, 2016). CRM is not a system which is important only for customer interaction but for all stakeholders, internal and external. Also, as (Lipiäinen, 2015) concludes: “CRM meant not only a technical solution to assist the customer process but also served as a modus operandi to take care of customers”. It would be great for one company if one CRM system could be set up as a wrap up of customer and interfaces with the customer. It would result in all information in one place. The following figure summarizes story about differences and roles of CRM in traditional manner and CRM in the digital age.

Also, idea is that company should establish good and clean BSS environment where each system will be optimized for its main purpose. The way of implementation has to follow market standards and market trends in order to have systems in an environment where it is easy to introduce a new product or even a new system. For example, for establishing new systems in the environment it would be helpful to create so-called northbound and southbound gateways. These gateways should be placed with a strict definition of the interface, followed by good documentation. Northbound gateway to be set up for connection of user interfaces. On the other side, southbound gateway to be designed for modular connection to backend systems. That approach would be very useful since new system will connect with only one legacy point which is already connected with all necessary backend systems.

Time-to-market for telecommunication companies needs to be very fast since that part of the industry is one of the most dynamic ones. Beside that lean BSS architecture is needed, introducing of configurable product catalog is must have at this moment. That kind of product catalog would allow shorter time-to-market for new products and services and let employees have time for exploring new technologies.

This paper is completely focused on digitalization, but important thing that in the era of digital transformation, communication companies surely should not marginalize phone call toward customer service or to any other – it is still the primary way of communication.

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POTENTIAL OF IMPLEMENTATION OF ICT IN MARKETING SECTOR – SERBIAN PERSPECTIVE

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Abstract: *This paper discuses Serbia potential in the domain of information and communication technology application in contemporary business with an emphasis on marketing function. The conducted research about the use of information and communication technologies in the Republic of Serbia and desk analysis, proved presence of the basic preconditions for steps necessary for implementation of digital marketing concepts for the everyday business of companies in Serbia, regardless of whether they do online business or not.*

Keywords*: marketing, internet, information-communication technologies, Big Data, research*

1. INTRODUCTION

There is a large number of professional and popular papers that emphasize something that is already intuitively recognized - a great influence of information and communication technologies (ICT) in modern business, starting with Joseph A. Schumpeter: Preface to Business Cycles, 1939 edition (Schumpeter, 1939; Zysman, 2005; Schermerhorn, Hunt, & Osborn, R., 2005; Applegate, Austin & McFarlan, 2007; Van Grembergen & De Haes, 2009; J. M, 2015; Vukmirović, D, at al., 2016; Vukmirović A., 2017).

Of course, Serbia as a candidate for EU membership and participating in negotiation process has also become influenced with the global economic flows. The indicators that show the level of technological development in Serbia are summarized through the following indicators (Digital Innovation Profile Serbia, 2018):

- ITU Global ICT Dev. Index 2017: rank 55 /176, score 6.61 /10
- Global Innovation Index 2017: rank 62 /127
- Innovation Efficiency Ratio: ratio 0.6; rank 67 /127
- Business Sophistication & Innovation: rank 110 & 95 /138
- Global Human Capital Report 2017: rank 60 /138

Main goal of the research presented in this paper is to determine the potential for the implementation of the modern ICT technologies in the Republic of Serbia. Research indicates the need for adopting the legal regulatory, specific lows and normative acts for implementation of data science technologies.

The results of the existing research indicate the significant potential that new technologies bring to the Serbian economy. Observed through the use of Internet technologies and social media, Serbian citizens are already using high-speed internet with the help of available technologies and services (primarily used to search information about goods and services and for reading online newspapers and magazines). There is a growing presence of both individuals and businesses on social media. The use of social networks such as Facebook and Twitter is steadily increasing in Serbia. When it comes to companies (enterprises) in the Republic of Serbia, research shows great interest and great dispersion in the use of ICT in everyday business (Kovačević, Pavlović, Šutić, 2017).

The conclusions that we considered are based on the analysis of the existing research, primarily one about the use of information and communication technologies in the Republic of Serbia, which was conducted by the Statistical Office of the Republic of Serbia in 2017, according to Eurostat methodology, on the territory of the Republic of Serbia, on a sample of 2800 households/individuals and 1655 enterprises.

The reference period for most of the questions given to companies was January 2017, while some of those referred to the entire 2016. It is important to emphasize this fact considering the speed at which certain technological solutions are being implemented in everyday business. The analysis also used the results of studies of Digital Innovation Profile Serbia centric ICT innovation ecosystem snapshot National Expert Assessment conducted by the Innovation Division of the ITU Telecommunication Development Bureau.

Recommendations derived from this study for further development of the ICT sector are accepted and we await its implementation

2. MARKETING CONCEPT IN THE MODERN ERA

Decades back, the former small businesses that had few customers, produced only one type of product, and offered it on the market always in the same way. With the development of industry and technology, there was a need for expansion. In this endeavor to expand, there have been major problems in the market research. Companies have struggled for long to find an appropriate system for collecting information about their customers, products and services, and at the same time attempted to solve the problem of storing the information they collected. Even if they collected the necessary data, it took hours, days, and even months to process and analyzes them.

These problems are not limited to the field of production, the problem of analysis and data management is manifested in all spheres of today's business, such as medicine, astronomy, politics, etc. The big problem is that we are facing with an increasing number of data, of which only 20% are structured and stored in rational databases, while the rest of the data (documents, images, videos...) stays unstructured. Companies need to consider different types of data sources. Some of them are sensors on which machines generate specific data, while other sources of information are those generated by people, such as data from social networks or click-stream data from different websites. In addition, the continuous development of technologies and mobile devices leads us to new data sources.

Digital data from a rapidly growing number of new technological data sources, such as mobile devices, social media and other digital applications are flooding the world. The advancements in computational, storage and analytical technology, as the tools necessary to handle and use that flood of data are now becoming available and more economical (Radenković at all, 2017).

The combination of enormous volumes of digital data and technological advancement are creating the new Marketing Era – Era of Big Data in Marketing (Apilleti & Forno, 2014; Aquino, 2012; Arthur, L. 2013).

Big Data is data so large, varied and dynamic that it cannot be handled by conventional data processing technology. By using advanced technologies to combine and analyze this type of data, information can be made visible that was undiscoverable in the past. According to authors, such as Mayer-Schönberger & Cukier (2013), firms, government and science can significantly benefit from this revolutionary way of knowledge discovery.

The private and science sectors are starting to use new technologies such as Big Data in their everyday marketing activities. Big companies from retail, such as Walmart (Bryant, Katz, & Lazowska, 2008), Sears (Henschen, 2012), and Amazon (Kelly, 2013) are now using Big Data in an attempt to better understand the customers and their purchasing choices. Nowadays financial institutions are using Big Data to accurately predict behavior on the market and investment performance. Online companies like Google, eBay, Alphabet (Amazon) and Facebook have created their marketing models based on the huge volumes of digital data determined on individuals' behavior, sentiment, information requests and preferences.

Regardless of the problem of the unauthorized use of private data by third-party companies facing Facebook these days and issues related to unfair competition due to the dominant position in the market, these large companies have established rules that the rest (followers) have to follow or at least try to get out.

In addition, in view of generating a large number of diverse data, companies are facing the problem of storing and analyzing large amounts of data, collected from different sources, in different formats. When we have so many different types of data, it is impossible to manage the data in a traditional manner. Data management needs to be thought differently, and that is exactly why we believe we entered the Big Data Marketing Cycle. Big Data enables companies to collect, manage, process, and store large amounts of data at high speeds. Big Data is a combination of evolution of the technology from 50 years ago.

3. ICT POTENCIAL IN THE REPUBLIC OF SERBIA

According to the research entitled Use of Information and Communication Technologies in the Republic of Serbia, conducted by the Republic Statistical Office in 2017, in accordance with the Eurostat methodology, on the territory of the Republic of Serbia, on a sample of 2800 households / individuals and 1655 enterprises The reference period for most of the questions asked to companies was January 2017, while some issues were related to the entire 2016. This is important point, taking into account the speed at which certain technological solutions are implemented in every day's' business.

Profile of the Serbian household in the field of ICT applications: 90.5% of households own a mobile phone.

Serbia has some of the highest penetration rates for mobile services in the Balkans and a competitive mobile market with three competing operators. The fixed telephony market has been liberalized relatively late (in 2010). The penetration of fixed broadband access to the Internet is still relatively low compared to the European average. The FTTH (fiber to the home) Council in Europe has recognized Serbia for reaching a commendable penetration of FTTH levels in excess of 1% (Digital Innovation Profile Serbia (2018) - ICT centric innovation ecosystem snapshot National Expert Assessment, Innovation Division of the ITU Telecommunication Development Bureau). 68.1% of households in Serbia possessed at least one computer in 2017, which was an increase of 2.3% as compared to 2016 (Figure 1) (Kovacevic, M, Kristina Pavlovic, K, Šutić, V., 2017).

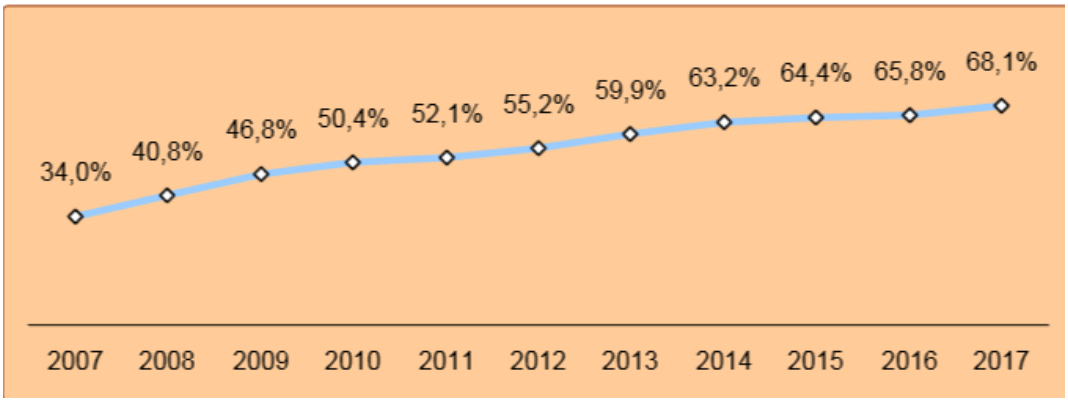


Figure 1: Percentage of households in Serbia owning at least one computer, per year

Computer use in households varies depending on traditional demographic factors: territorial integrity, standards and education of the household head. The biggest gap in the presence of computers in households is present when the stratification is done according to household's monthly income. Households with above-average monthly income (over 600 euros) own a computer in over 95% of cases, while the shares of households with income lower than average (up to 300 Euros) is only 50%. This data indicates that potential consumers with higher purchasing power in Serbia are virtually completely online. It is similar with the penetration of the Internet in households, where it was noted that 68% of Serbian households have an internet connection in their homes (Figure 2).

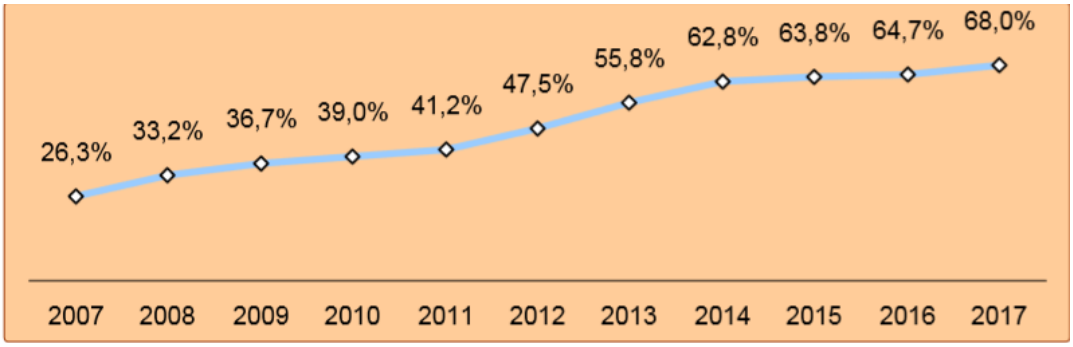


Figure 2: Percentage of households in Serbia having an Internet connection, per year

As a reason they do not have internet access at home, the 70.0% of households said there was no need for the internet, 24.4% of households stated that equipment is expensive, while 22.8% of households said they lack the skills.

The method of accessing the Internet (types of connection) in households is shown in Figure 3. It is important to emphasize that 61.9% of households in Serbia have a broadband internet connection.
Also, there is a growing presence of mobile devices with access to Internet services, which is in line with global trends. That fact points out what is the direction for development of integrated marketing programs in these regions.

The habits of Internet users in Serbia are increasingly moving from information to communication - social media and making calls (voice and video), while, roughly a quarter of the online population uses internet technology for purchasing and little less than that for online banking.

The survey found that almost 20% of the internet population in Serbia finds a way to store an ever-increasing amount of data that they manipulate on a daily basis, either for private or business purposes, using cloud technologies (Google Drive, Dropbox, Windows Skydrive, iCloud).

When it comes to companies in Serbia, it is important to emphasize that 100% of companies use a computer in their business. In addition, 81.9% of enterprises use mobile broadband internet connection (3G or 4G) with usage of portable devices.

80.4% of companies operating in Serbia owned the website in 2017. (93.6% of the big size, 92.1% of medium-sized enterprises and 76.9% of small businesses own a website).

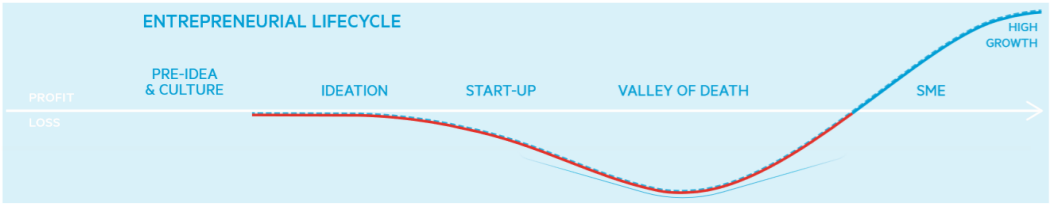
Observing B2B transactions in Serbia it can be concluded that:
- 41.4% of companies in 2016 ordered products / services via the Internet
- 23.8% of companies during 2016 received orders via the internet.

Social networks are increasingly present in everyday business in Serbia – 39.2% of companies used one of the social networks for their business needs.

Willingness to use open-source operating system has stagnated in recent years, and in 2017, 20% of the companies use open-source Linux operating system, which is at the level from 2013. It is interesting to note that large enterprises are leading in the use of open-source technologies in Serbia (41%). 9.3% of companies in Serbia use cloud-based services which are paid on the Internet.

4. FURTHER STEPS

These results indicate that there is no time for waiting- Serbian companies must take a step. Serbia's small core of highly-skilled and experienced IT development companies can generate growth and opportunity, helping Serbia's brands to become attractive to foreign investors, and inspiring other IT firms in the country. Major areas of strength for Serbian companies are financial services applications and industrial applications / process control. Serbia is starting to emerge as a distinct and positive brand in these areas (Digital Innovation Profile Serbia, 2018).



ENTREPREN. PHASE / STAKEHOLDERS	PRE-IDEA & CULTURE	IDEATION	START-UP	VALLEY OF DEATH	SME
ENTREPRE-NEURS	ENTREPRENEURIAL INTEREST	ENGAGE WITH PROBLEMS	DEVELOP BUSINESS MODELS	BUILD COLLABORATION	EXPAND
FINANCE	RESEARCH FUNDING	SEED FUNDING	ANGEL INVESTMENT	VENTURE CAPITAL	BUSINESS FINANCE & LOANS
ENTREPRE-NEURIAL SUPPORT	ENTREPRENEURIAL EVENTS	HACKATHONS & COMPETITIONS	CO-WORKING & SUPPORT	INCUBATORS & ACCELERATORS	BUSINESS ASSOCIATION
PRIVATE SECTOR	SUCCESS STORIES	RESEARCH PROGRAMS	LAB PROGRAMS	B2B & SUPPORT SERVICES	SKILL TRAINING PROGRAMS
ACADEMIA	ENTREPRENEUR COMMUNITY	BASIC RESEARCH	SPIN OFFS	SOFT SKILL TRAININGS	HUMAN CAPITAL
PUBLIC SECTOR	VISION & STRATEGY	IP & R&D SUPPORT	TAX SUPPORT	PUBLIC PROCUREMENT	TRADE POLICY

Figure 3 Innovation Journey Map – Serbia (Digital Innovation Profile Serbia, 2018)

If we begin with Innovation Journey Map – Serbia we see that the Innovation Journey Map sets out the work that needs to be done within the ecosystem in order to harness innovation on a transformative journey from pre-ideation to high growth. It describes each stakeholder's role (green), inadequate (yellow) and missing / weak (red).) Figure 3. We can conclude that the digitization of the Serbian language market place has taken great power. The fact that much has yet to be done just, still gives a chance for those businesses which have not been part of this process to catch their last chance to do so.

5. RECOMMENDATION FOR ACTION

Regardless of the limitations and perhaps disappointed expectations by some, Serbian companies had to welcome influx of new (big data and other) technologies.

Further Steps on micro level:
- Creating Strategic Documents - Big Data and AI Initiative,
- Open Data; Developing private-public-academic partnerships
- Education - education system - including dual education - not only for highly qualified

Further Steps on macro level:
- Companies cannot achieve all this alone. It is on the state to help them
- What has been done so far by the state (Digital Innovation Profile Serbia (2018)
- Connecting schools to AMRES (Academic Network of the Republic of Serbia)

The recently launched initiative 'Development of ICT infrastructure in education, science and cultural institutions' is in the process of connecting all schools in the country to the Academic Network. 1800 institutions in Serbia receive free and secure internet, active protection, and online support, including access to international electronic education services.

The 'Smart and Safe' platform, recently launched by the Ministry of Trade, Tourism and Telecommunications, aims to raise awareness of the importance of citizen engagement with the education system and the greater digital economy. The platform launches educational and promotional projects designed to support digital literacy, digital competencies and digital security culture throughout Serbian society.

The National contact center for the children safety on the internet, launched by the Ministry of Trade, Tourism and Telecommunications is based on regulations governing the protection and safety of children using new technology. This unique resource offers advices, help, information and research to children, parents, teachers and other relevant individuals in regard to online safety.

Digital Innovation Profile Serbia (2018), ICT centric innovation ecosystem snapshot National Expert Assessment, among the others states that the Republic of Serbia should support the ICT sector in its effort to succeed in this matter (Digital Innovation Profile Serbia 2018):
- Economic results and other data indicate the necessity for government's action in support of the ICT ecosystem with following:
- Establishing incentive structures as part of an environment designed to help ICT innovation converge with other technological innovations – with the clear objective of overall strengthening of the Serbian ecosystem.
- Affordable and accessible high-speed broadband is an important enabler for competitiveness across many areas including education, health, entertainment – and for general social cohesion. This places Serbia among countries that need to develop broadband infrastructure further and promote digital technologies in business.
- The primary objective of the Republic of Serbia is to achieve sustainable and dynamic economic development across technology and manufacturing in line with European Union targets, while able to withstand competition from its members. To achieve this, the government has adopted a number of strategies designed to boost ICT and progress towards a knowledge-based economy. The 'Strategy for the Development of Next Generation Networks (NGN) in the Republic of Serbia to 2023' has been drafted, which includes fibre as an essential element of the future infrastructure to meet growing demands for bandwidth.

6. CONCLUSION

Finally, it can be concluded that modern approach to marketing undoubtedly indicates that the development of marketing functions is directly correlated with the development of information and communication technologies, and that the results of the research indicate that this degree of dependency will increase even further. The perspectives of Serbia cannot be seen in a different way, which is also shown in the analysis of the research that has been synthesized in this paper, that further on points to the necessity of applying modern information ICT in everyday business and marketing. Internet and mobile technologies, Big Data and further development of artificial intelligence will accelerate the application of modern (not only informational) technologies in everyday business. This implementation has already encompassed all the spheres of a modern society, and not only in areas where expansion primary happened, such as social media. The boundary between online and traditional business (brick and mortar) is being lost increasingly. Amazon, for example, switched from e-business to other more profitable spheres of business, such as film production. The car industry records show dramatic changes, which are not only characterized by the transition to a new

motor fuel, but also by the basic service - switching from the purchase of cars as a vehicle to the future car that becomes a means of communication. Airbnb, Uber, Tesla and numerous successful start-up companies point out that business models based on new technologies dramatically change the traditional ways and philosophy of business. They have also accelerated development of infrastructure (Big data, cloud, mobile platforms and the use of business intelligence (BI), which, on the other hand, leads to the abolition of existing and creation of new, different jobs). Also, Crypto currencies change the basic operating premise of global economy.

This paper recommends the legal and strategic frame for the usage and implementation of data science technologies on institutional level and by private sector companies. Research has indicated the need for updating the education system in order of better implementation of e-business technologies such as Big Data, artificial intelligence and etc. Framework methodology for the development of Big Data concept for conducting research in the Republic of Serbia was presented.

By considering the objectives of the digital sector in Serbia (see (Digital Innovation Profile Serbia, 2018), it can be concluded that companies in this region have yet to capture a connection with the European average standards.

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MOBILE APPLICATION DEVELOPMENT FOR INTEROPERABLE LOYALTY MANAGEMENT SYSTEM

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Abstract: *This paper presents an approach for development of interoperable mobile loyalty application that resolves three aspects of interoperability: syntactic, semantic and technical. The main goal is to develop loyalty management system as an interoperable and digital system. This systemwill allow the development of different applications and enable communication with various loyalty programs provided by different companies. The case that is being considered is implementation of loyalty mobile application in Android OS. This application uses mobile application architectureas one of interoperability frameworks. This type of architecture helps to connect all participants in loyalty management system and makes dataexchanging process between themmuch easier. Some significant features are described in implementation of a loyalty application.*

Keywords:*interoperability, loyalty system, Mobileapplication architecture, Android, qr code*

1. INTRODUCTION

Loyalty system can be understood as a new business philosophyand a strategy, which allows getting new customers, retaining the trust of customers, personneland partners in the process of mutually beneficial cooperation based on participants' voluntary actions. The main idea through this cooperation process with customers, personnel and partners is to offer them product or service that will satisfy their needs. (Tiina Jokinen, 2014.). Existing loyalty systems are composed of different applications that are independently built (at different times, by different teams, using different technologies).There are problems in the exchange of data when moreapplications are in the interconnected relationship. Development of interoperable applications solves problems in exchanging data.

There are various software solutions for loyalty programs, which are integrated and which are not considering the aspect of interoperability. Related work (Software Advice, 2018) presents lists of software with customer loyalty programs,focusingon specific company. Our goal is to developthe loyalty management systemas an interoperable system. This system would allow the development of various applications and it would enable communication with different loyalty programs, provided by different companies.We also strive to be innovative and to reinforce technology in a modern way. To achieve this, we use mobile application architecture to innovate processes and business models.

The term "interoperability" is defined as the ability of two or more systems or components to exchange information and to use exchanged information (T. Benson & G. GRIEVE 2016.).In the context of businessapplications, interoperability is defined as the ability of a system or product to work unmodified with other system or product, without the need for special effortsfrom the user(Techtarget, 2018.).

The interoperability is categorized in two basic categories: syntactic and semantic interoperability (ECOTECH, 2018.). If two or more systems are capable of communicating and exchanging data, they are exhibiting syntactic interoperability. Specified data formats and communication protocols are fundamental. XML,JSON or SQL standards are some of the tools of syntactic interoperability. This is also true for lower-level data formats, such as ensuring alphabetical characters are stored in a same variation of ASCII or a Unicode format (for English or international text) in allcommunicating systems. Semantic interoperability is the ability of two or more systems to exchange and automatically interpret the information, exchanged meaningfully and accurately, in order to produce useful results, defined by theusers of both systems. To achieve semantic interoperability, both sides must refer to a common information exchange reference model. (Ecotech, 2018.)

This paper represents the possible approach, through the example of the implementation of modern mobile architecture, to provide the answer to the question of the problem of interoperability. This work certainly would not be possible without defining a real problem,which has been mentioned in Section 2.Proposed approachand the mobile application architecture have been discussed in Section 3, while implementation of loyalty mobile application and most of the code excerpts with detailed picture have been given in Section 4 of the paper. Conclusion and potential further work are presented in Section 5.

2. DESCRIPTION OF THE PROBLEM

This section describes problems that need to be resolved,so we can achieve interoperability of applications.One of them is a problem of description of real system for loyality programs.

Nowdays, people use some loyalty program daily. In general, they get traditional paper or plastic card thatidentifies the card holder as a participant in a loyalty program. Unfortunately, people usually forget where they put their cards or they simply lose it.In addition, there are a lot of loyalty programs and people are participating in more loyality systems by different companies.As a result , they are losing interest in loyalty card programs.
Also, companies or facilitiesthat offer loyalty programs to their customers, don't have well-developed monitoring system and access controlfor customers and employees.

Therefore, there is a need to develop a loyalty applicationthat should be interoperable and distributed (Figure 2). Loyalty application would enable communication between customers andagents from central Loyalty Management systems. Also, it's necessary to provide communication between agents of different companiesthatcould cooperate together and provide some discounts or rewards for customers. This would require companies to agree with a form of cooperation or a contract that defines a discount or a reward. For customers, it is important to have more cards from different companies, that provide different loyalty programs. They want to have an insight into their own card transactions andthey want to be able to monitor history of their transactions.
Loyalty application should have some features such as: recording transactions,different rewards based on customer, partner, program, tier and product, web portals for administration, standard email and communications set up within the program (Simplicity, 2018.).

There are three main entities in the loyalty system: customer, loyalty application and point-of-sale. Customer uses mobile device to accessloyalty application in order to see his different cards with stamps. Companies provide loyalty programs and define rewards and discounts for customers. Point of sale are places that execute giving stamps to customers. Point of sales can be distributed across different regions and they communicate to each other, if they belong to the same region. Gateways are agents that enable communication and synchronize data between central end points and point of sales.The loyalty application is connected through gateway and it exchanges data with point of sales.

The loyalty application should cover three aspects of interoperability on technical, syntactic and semantic level:

- Technical interoperability: At this level of interoperability, there are communication protocols for data exchange between the systems and through those the communication infrastructure for the exchange of bits and bytes happens. The basic networks and protocols are defined unequivocally.
- Syntactic Interoperability: If two or more systems are able to exchange data, they show syntactic interoperability. There are basically defined data formats and communication protocols. Examples of syntacticinteroperability are XML and JSON standards. Syntacticinteroperability is required for ensuring a higher level of interoperability.
- Semantic interoperability: Ensures that two or more computing systems are capable of exchanging information automatically, in a meaningful and precise way and to interpret shared information, so thatuseful results would be produced, in accordance with the requirements of end-users. To achieve semantic interoperability, both parties must respect the reference model for information exchange. During the exchange of information, the content requirement is definitely defined: a set of sent information, in terms of meaning, must be recognized and mapped into a set of information received (H. Kubicek 2011.).

3. PROPOSED APPROACH

There are several ways to achieve interoperability. Generally accepted ways to solve interoperability issues are: standards, interoperability frameworks, frameworks for the architecture of company information systems; semantic technologies based on ontologies, as well as the service orientation (Zhiying Tu, Gregory Zacharewicz, David Chen 2016).

Following steps, in order to solve interoperabilityproblems of applications,are:

- Need to define logical and physical design of information system. Logical design of an information system is an abstract representation of the data flows, inputs and outputs, while physical design relates to the actual input and output processes of the system.
- Using framework for interoperability. The interoperability framework can be defined as a set of standards and guidelines that describe the way in which organizations have agreed or should agree to cooperate together. The interoperability framework is not a static document, but over the time, it must adapt to

changes in technologies, to standards and administrative requirements (EUROPEAN COMMISSION, 2017.). Framework for interoperability is a part of the architecture of information systems and it deals with the integration and connection of elements. In this paper, focus will be on mobile application architecture, due to the need to make the application available for customers.

- Create interoperability gateway. The interoperability gateway is a channel designed to interface the Internet Protocol (IP) network with applications. Applications are connected to HTTP protocol and data can be interchanged.
- Mapping and data transformation. Data transformation is the process of converting data from one format (e.g. a database file, XML documentor Excel sheet) to another. Data transformation is necessary to ensure that data from one application or database is intelligible to other applications and databases, which is a critical feature for applications' integration. The first step of data transformation is data mapping. Data mapping determines the relationship between the data elements of two applications and establishes instructions for the way the data is transformed from the source application before it is being loaded into the target application. In other words, data mapping produces the critical metadata that is needed before the actual data conversion takes place (MuleSoft, 2018.).

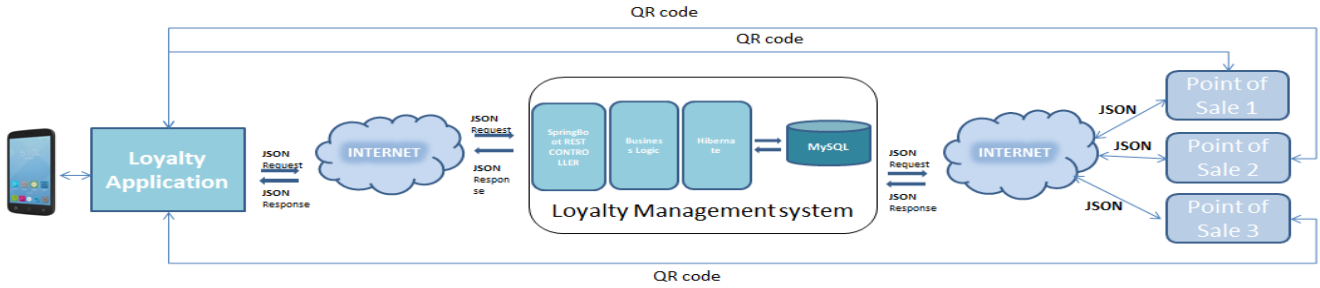

Figure 1: An approach proposed for mobile application development for interoperable loyalty management system

Based on mobile architecture, loyalty application should cover all loyalty programs provided by different companies. On the Figure 1, you can see a mobile application, connected with Loyalty Management system via IP gateway. In addition, the loyalty application communicates with point of sale through different qr codes. Point of sales have data for their own customers and they provide synchronization data with Loyalty Management system. Transformation of the data is released by using JSON format and REST service.Loyalty Management system is independent application which consists of business logic layer, REST API service and database layer. Database layercommunicates with MySQL database.

3.1 Mobile applicationarchitecture

Mobile application architecture is one of the aspecta of general architecture. The applications should be implemented in a syntactic, semantic and technical way that leads to interoperability improvements. Mobile application architecture is used as the main part of the interoperability framework and the focus will be on it. In the other hand, server architecture will be presented on abstract level, in order to show how mobile application architecture solves interoperability issues in technical, syntactic and semantic level, using interoperabilitygateway.

Mobile application architecture, consisted of application, application frameworks, libraries and kernel,is shown in Figure 2. Applications can be divided into two parts – native apps that provideOS and user apps. In the Figure 2, presented are the applications such as camera, contacts, e-mail and browser. The application framework provides many higher-level services to applications. This framework implements the concept that apps are constructed from reusable, interchangeable and replaceable components. This concept has been taken a step further in a sense that application is also able to publish its capabilities along with any corresponding data, so that they can be found and reused by other applications. The application framework includes the following services: Activity Manager which controls ll aspects of the application lifecycle; Window Manager handles screens; Content Providers allows applications to publish and share data with other applications; Notifications Manager allows applications to display alerts and notifications to the user; Location Manager provides access to the location services, allowing an application to receive updates about location changes (Techotopia 2016.). Libraries provide support for tasks such as string handling, networking, file manipulation. scanning, database access etc.They are specific for mobile development and they differ in the OS. Kernel OS provides a level of abstraction between the device hardware and it contains all the essential hardware drivers, such ad camera, wi-fi, display etc. Also, the kernel handles all the things, such as networking and a vast array of device drivers, which resolves the issue of interfacing to peripheral hardware(Techotopia 2016.).

In the middle of the Figure 2, there is a gateway which connects mobile and server side. Gateway uses network connection standards such as HTTP protocol (Pavan Podila 2013.) and provides exchanging data at the technical level.

On the bottom of the Figure 2, server that gets requests, transforms data,extracts data from database, makes and sends response to mobile application is represented. This way, itcovers interoperability issues on syntactic level byusing JSON data interchange format.
On the both sides, a common model of designed information system is applied. This model represents agreement between all applications on terms, that they can semantically parse. That way, it resolves interoperability issues on semantic level.

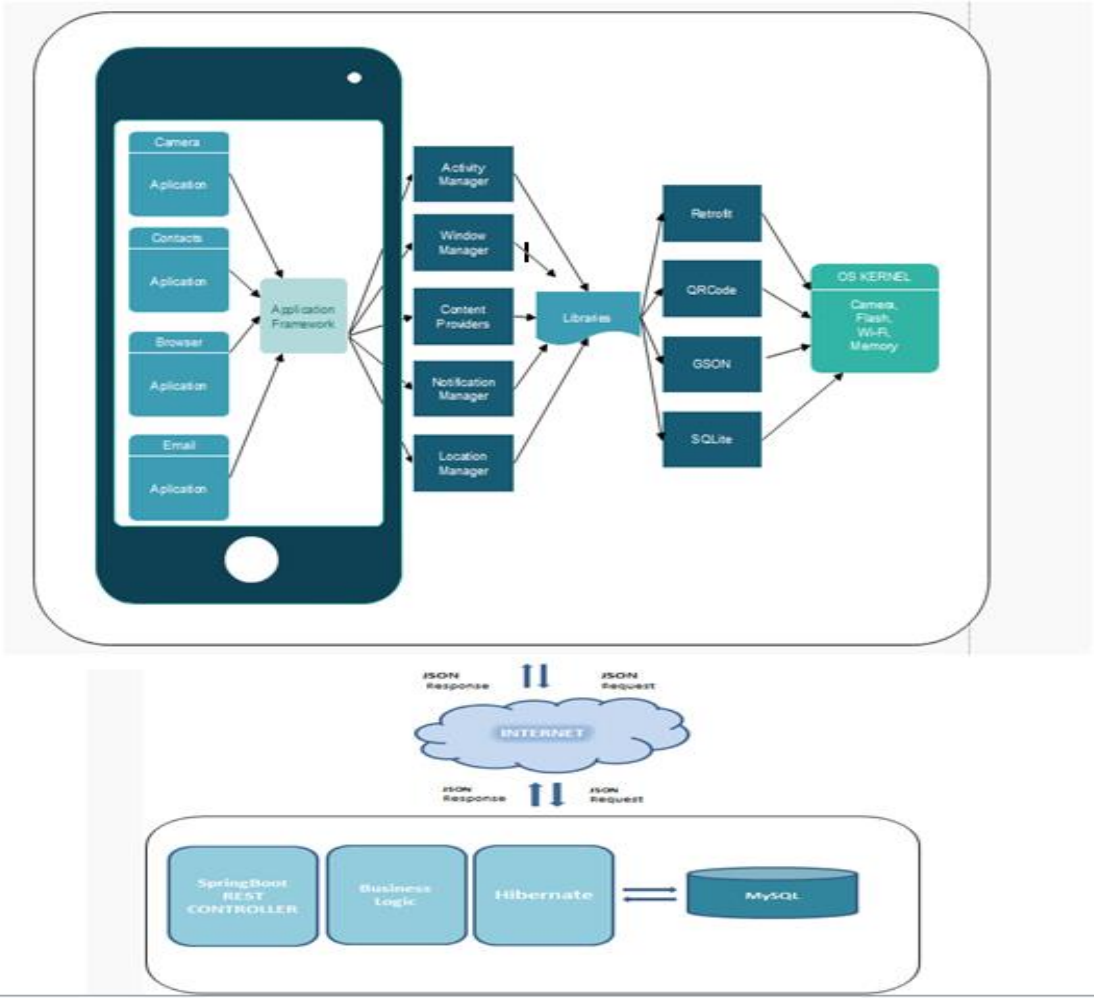

Figure 2: Mobile application architecture

4. IMPLEMENTATION OF LOYALTY MOBILE APPLICATION

In this section is demonstrated implementation of mobile loyalty application based on Android OS. The mobile application becomes an important software delivery model which integrates front-end user interfaces with back-end RESTful services (Shang-Pin Ma, Chi-Chia Li, Chen-Yuan Fan,Wen-Tin Lee, Nien-Lin Hsueh, 2016.).The loyalty applicationuses mobile application architecture as framework for interoperability. Logical and physical design was used to develop the methods and model for enhancing interoperability among applications. In general,it is needed to define standard model which will describe state and behavior of observing system.

Implementation of loyalty mobile application resolves interoperability issues of applications on technical, syntactic and semantic level. Figure 3 shows simple overview of the loyalty application in Android OS. The loyalty application is useful and simple solution that represents a digital platform, where every employee could have his own digital signature and where he could set his stamp on customer's account. This application helps digital transformation, which means conversion of analog physical objects, such us

traditional paper or plastic card, into digital objects on mobile device.The loyalty application is consisted of different loyalty programs provided by different companies. Customer with mobile device and installed app goes to some stores and when he scans QR code for the first time, he getsa ready card, with validated stamps by server.

On the Figure 3,Android user who scans QR Code is presented. The loyalty application uses QRCodeReaderView application as an internal project to provide scanning. This includes Camera API, which is specific for OS kernel. When user scans code, the value is taken and sent via Retrofit. Retrofit library provides API calls and processes requests and responses. Format for data exchange is JSON. On the server side is REST controller, which serves user and communicates with business logic layer. On business logic layer, the common model is defined, that has shared data dictionary and defined types of data. This model helpsthe transformationof data beetwen mobile application and server-based application. Hibernate layer communicates with MySQL database, excutes SQL queries and mapping properties.

When qr code is validated, server makes JSON response with stamp and sends customer's card as an object. This object is rendered by Picasso library and shown as card with stamp onthe customer's user interface.Customer has a lot of cards from different companies. Also, customer in app installed on his device can see histories of his rewards or discounts.

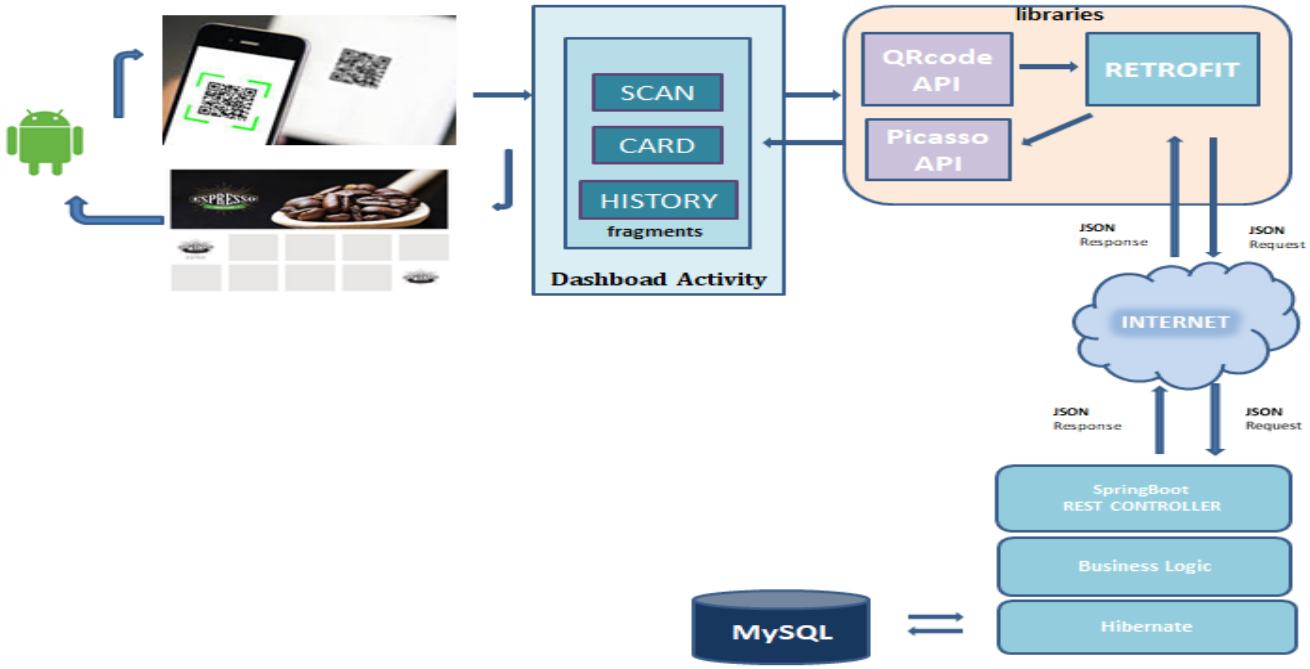

Figure 3: Loyalty application with main focus on mobile application architecture

4.1 Realization

The loyalty application is implemented in Android OS. When an application is created, build system automatically takes all the source files (.java and .XML), then applies the appropriate tool (for example, gets java class files and converts them to Dalvik Executable files with .dex extension) and groups all of them into one compressed file with APK extension. Significant part for developers is build.gradle (Module:app), which sets default configuration, such as minimal version of Android system on which the application can be installed, version name and code, build types. Build.gradle tool determinates and imports the dependent libraries such as Retrofit, Picasso, Card View etc.

The settings.gradle file is located in the root project directory and executed before any build.gradle and even before project's instances are created.The settings.gradle informs gradle which modules it should include when buildingthe app. In addition to the standard app module, qrcodereaderview module is also included.

```
include ':app','qrcodereaderview'
```

Below it will be explained how to interoperate these two modules in process of scanning qr codes.

- QRCodeReaderView class uses ZXING lib (Barcode Scanner) and integrates a QR decoder view. In this class, methods such as: start and stop camera using by CameraManager; set autofocus interval, set front or back camera and creating a qr code reader are implemented. Also, listener is specified and listens when qr code is read.

Public class QRCodeReaderView extends SurfaceView implements SurfaceHolder.Callback, Camera.PreviewCallback { public interface OnQRCodeReadListener { void onQRCodeRead(String text, PointF[] points); }

- In the ScanFragment (Figure 4) class of loyalty app, QRCodeReaderView is defined andOnQRCodeReadListener is implemented.
- QRCodeReaderView represents view for user's interface and it is defined in XML format. <com.dlazaro66.qrcodereaderview.QRCodeReaderViewandroid:layout_margin="10dp" android:id="@+id/qrdecoderview" android:layout_width="match_parent" android:layout_height="match_parent" /> This view in fragment is defined and binded using ButterKnife anotations @BindView(R.id.qrdecoderview)QRCodeReaderView qrCodeReaderView;
- OnQRCodeReadListener override onQRCodeRead method which gets value of scanned qr code. After that, given value is sent to server that will check it and validate it.

@Override public void onQRCodeRead(final String text, PointF[] points) { LawaApp.getApi().scanning(Constants.CLIENT_TYPE,LAWAPref.GENERAL.getPref().getString(Keys.UserK .ID), TimeUtils.writeDateAndTime(dateTimeNow), text.trim(), clientGroup, new Callback<List<Scan>>() {}}

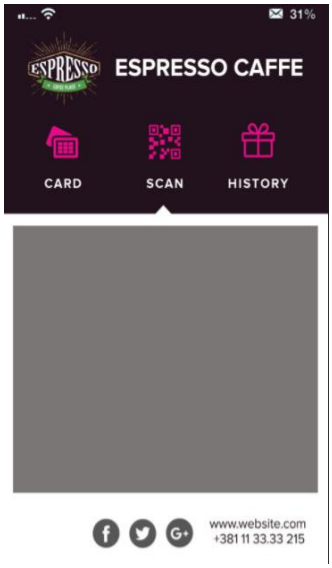

Figure 4: Screen fragment

5. CONCLUSION AND FUTURE WORK

This paper presents an approach for development of interoperable mobile loyalty application that resolves three aspects of interoperability: syntactic, semantic and technical.Proposedapproach has several steps. First of all, it is necessary to pass through the logic and physical design of the IS to determine the state and behavior of the system that is being observed. The ultimate goal of design is to get a common standard model through which applications can communicate and share data.Following, to apply framework in this case of mobile architecture and to define gateway for transmition data. The last step is making decisions how tomap data between applications.

To verify proposed approach, an example of the mobile applicaton is presented. It is a loyalty application implemented in Android OS. The main focus is onmobile application architecture, but it also describes cooperation with server side. It is shown as an implementation of one functionality of mobile application: scanning qr codes. The loyalty application has also local database which synchronizes data with server when is in offline mode. In that case, it implements two gateways, one with loyalty application on mobile side and two with server side. This feature enables the user to use application without Internet. The development of application core took about two months, gathering materials and implementation took additional ten days, while the extra week was spent for fixing bugs and code optimization.

There are several ways for future development. In one of the following stages, it's planned to create a location service for getting current user's location, based on mobile application architecture which will be interoperable with loyalty application. Location service feature can offer customers discount and deals when they check in, walk into a store and scan their qr codes. Also, there is a concept of an application with recommendation service. For example, this app may recommend location of the store to customer, if he is near it and it can provide discount that way.

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SAFE AGILE FRAMEWORK IN E-BUSINESS PROJECT MANAGEMENT

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Abstract: *The aim of the paper is to explain the fundamental concept of Scaled Agile Framework (SAFe) and to help to understand which methodology should be used in project management in e-business. A large number of organizations has published and claimed to be "agile" or to plan to use the agile method, but there is some confusion regarding using of this concept. The main goal of the paper is to clarify what SAFe actually means and which necessary steps must be performed toward SAFe implementation. Also, this paper analysis risks which must be taken into account during the design and implementation of SAFe. The focus has been given on SAFE implementation in software projects. In conclusion, the benefits of implementation of SAFE in large organizations are described.*

Keywords*: Scaled Agile Framework, project management, Agile Release Train, agile methods, SAFE implementation, Scaled Agile, Inc.*

1. INTRODUCTION

The goals of the paper are to show the framework for scaling agile principles, its key elements and factors, to explain the benefits of managing projects in e-business using SAFe, and to clarify briefly the implementation of SAFe. Understanding the methodology such as SAFe, and its implementation in proper manner in e-business opens the plenty of possibilities and provides a foolproof opportunity for continuous success and maintaining competitiveness in the global market.

One of the first decisions we face when launching each project is "What development methodology should we use?". Agile methodologies have begun to develop 15 years ago. Agile is a specific type of rapid development and it is newer than the "traditional" waterfalls (Lotz, 2013).

A large number of organizations has published and claimed to be "agile" or to plan to use the agile methods. Agile software development has made a quiet revolution in project access and management. Due to the general trend of accepting optimization and reduction of activities which are not of a high priority and do not bring value, agile methods are most often well accepted by the senior management and the project team (Jovanović, 2017).

Implementation of agile methods significantly alleviates organizations to develop software for customized services and products in e-business. By using agile methods, organizations gain a competitive edge and the ability to adapt to current market trends. Furthermore, in this way the organizations can even improve their flexibility.

Scaled Agile Framework is an agile framework for project management. The product is made by Scaled Agile, Inc. In Scaled Agile Inc. SAFe development activities are based on the key belief that: "better systems and software make the world a better place." Their mission is to help those who build these systems through the development and publishing of the SAFe framework, as well as through the accompanying certification, training, and courses (“What Is SAFe?”, 2017).

SAFe aids e-businesses to deal with significant challenges in developing and delivering software designed for large-scale systems in the shortest implementation time. It is an online knowledge base with proven patterns for achieving success. SAFe synchronizes and provides synchronization, collaboration and delivery products for multiple Agile teams. Scalable and configurative, SAFe allows each organization to adapt it to its own business needs. SAFe is suitable to support small solutions which are used by 50 to 100 users, as well as complex systems with thousands of people. It describes the roles, responsibilities, artifacts, and activities necessary for the implementation of Lean-Agile development.

The main goal of the paper is to show the framework for scaling agile principles, its key elements and factors, to explain why it is important to manage projects in e-business using SAFe, and to briefly clarify the implementation of SAFe.

2. SAFE

The philosophy of SAFe is simple: the ultimate responsibility for the adoption, success and continuous improvement of the efficient and agile (Lean-Agile) development lies in existing managers and managers of the company. Only they can change and continuously improve the systems in which they all work. In order to achieve this, leaders must be trained and in parallel they become trainers themselves, with improved ways of thinking and working. Some of them need to offer a new leadership style, the one that really teaches, empowers and engages individuals and teams to achieve their greatest potential (Knaster & Leffingwell, 2016).

SAFe Lean-Agile Leaders are lifelong learners and teachers who assist teams in building better systems through understanding and exposing Lean-Agile thinking (Lean-Agile Mindset), SAFe principles and thinking about systems (Campbell-Pretty, 2016). Such leaders show the following behavior:

- Introduce and guide the changes
- Know the path
- Lifelong learning
- Develop people skills
- Inspire and align with the mission
- Minimize constraints
- Decentralize decision making
- Motivate workers to develop a constant need for learning

The Community of Practice (CoP) was formed within the framework of SAFe. It is an informal group of team members and other experts who work within a program or enterprise with a mission of sharing practical knowledge in one or more relevant areas. They regularly cooperate with the goal of sharing information and improving the skills and further they actively work on improving their knowledge from their domain ("Communities of Practice", 2017).

The entire work under this methodology is based on Core Values, which represent the basic beliefs of a person or organization. Basic values are the guiding principles that dictate behavior and action. Basic values can help people to recognize what is right and what is wrong, what to focus on. Moreover, they can support companies to determine whether they are on the right track and whether they fulfill their business goals. Lean-Agile set of views, Lean-Agile leaders, SAFe principles as well as the extensive advantages that Lean-Agile development provides to everyone, play important roles in defining what makes SAFe successful (Leffingwell, 2016).

Most of Lean's thoughts are presented in SAFe House of Lean. Lean's house is made up of six key constructions. "Roof" is the goal of achieving value; "pillars" support this goal by respect for people and culture, flow, innovation, and improvements. Lean-Agile Leadership provides the basis on which pillars and goal are built up. The details of Lean's house are shown in the Figure 1.

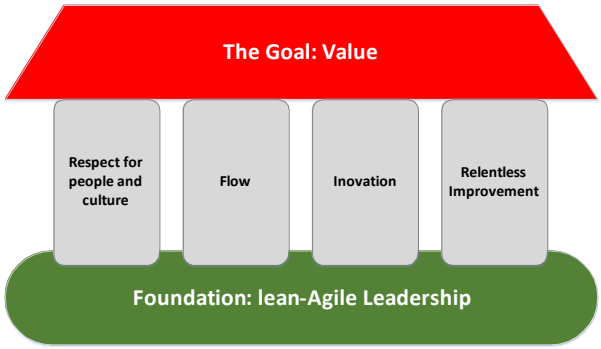

Figure 1: House of Lean

SAFe is based on series of unchangeable, basic Lean and Agile principles. These are the basic principles, basic truths and the economic fundamentals that set off roles and practices making SAFe so effective. These nine principles are:

- have an economic view i.e. observe the situation from the economic point of the view
- apply systematic thinking
- anticipate variability
- progress incrementally with fast integrated learning cycles
- evaluate the system objectively
- perform graphical presentation of the scope of work and its limitations

- cadence application, domain-level planning synchronization
- accelerate the internal motivation of members
- decentralize the decision-making system

2.1. SAFe Portfolio

All of the above mentioned principles have been used to present a broad range of development environments through four configurations that companies can adapt and implement in their business. Those are:

- Basic SAFe
- SAFe Portfolio
- Large Solution SAFe
- Full SAFe

The SAFe Portfolio has been most frequently applied. The SAFe Portfolio assists to align the execution of the portfolio with the company strategy by organizing agile development around the flow of values through one or more value streams. This provides business agility through principles, practices, portfolio strategy, as well as investment financing, agile program guide, and Lean management. The architecture of the SAFe portfolio consists of three levels: portfolio, program, and team (Figure 2).

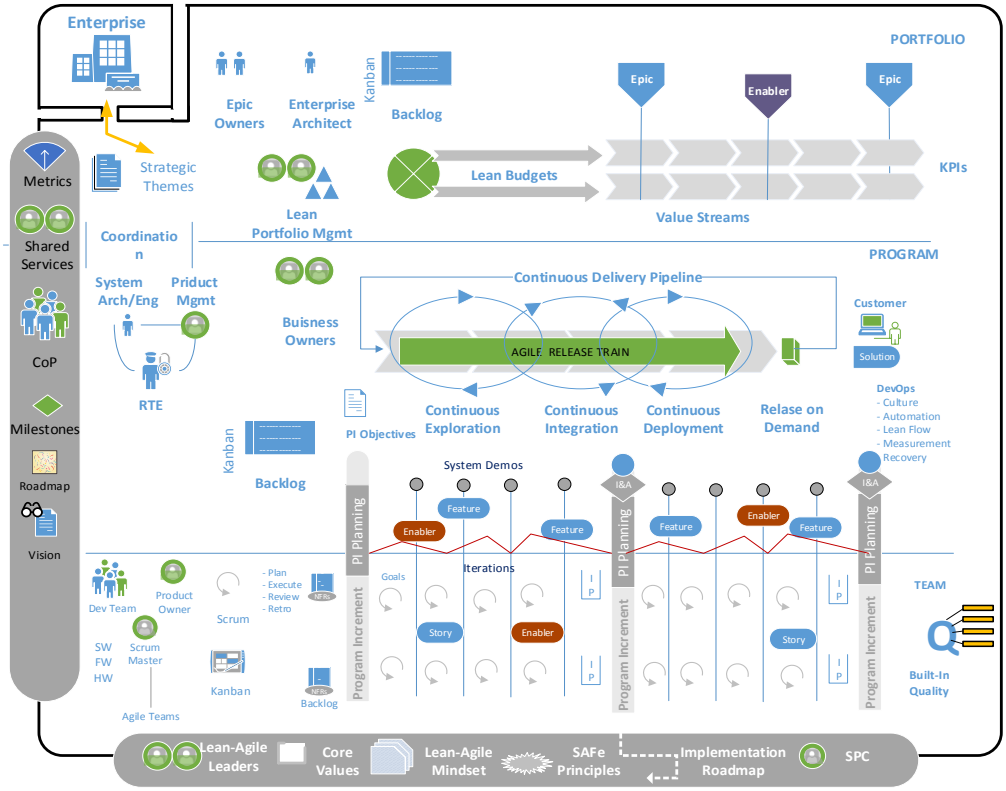

Figure 3: SAFe Portfolio

The PORTFOLIO level organizes and finances a set of value streams. The portfolio provides funds for solution development through Lean-Agile budgeting and the necessary coordination and management of value streams ("Portfolio Level", 2017). The portfolio level contains principles, practices, and roles needed to initiate and manage a set of development values. This defines financial assets and investments in value streams and their solutions. This level also provides Agile portfolio operations and Lean's management of people and resources needed to supply a solution. The portfolio level harmonizes the company's strategy with portfolio execution by organizing the Lean-Agile company around the flow of value through one or more value streams. By providing basic budgeting and necessary management mechanisms, it allows investment in solutions to guarantee a return on investment (ROI) in order to realize the strategic goals of the company.

The PROGRAM level contains the roles and activities necessary for continuous provisioning of the solution through the Agile Release Train (ART). At the program level, development teams, stakeholders, and other resources are dedicated to an important, ongoing mission to develop a solution. ART describes teams, roles,

and activities of the program level that gradually bring a continuous flow of values ("Program-Level", 2017). ART is a virtual organization formed to pass functional boundaries, to eliminate unnecessary handover steps, and to accelerate the achievement of value using the SAFe Lean-Agile principle in practice. Although called a programming level, ART is long lasting and hence (therefore) has a more persistent self-organization, structure, and mission than a traditional program. Usually, the program has a definite start and end date, as well as temporarily allocated resources.

The TEAM level contains roles, activities, events, and processes that Agile teams build and deliver in the context of the Agile Release Train (ART). All SAFe teams are part of ART, the primary level of the program level. The roles and functions of ART, including Release Train Engineers, product managers, system architects, engineering, system team, and common services facilitate all teams on the train. As a result, they are fully capable of defining, developing, testing and delivering working and tested systems in every iteration. Each Agile team is responsible for defining, building and testing Stories from their backlog team. Stories are short descriptions of small parts of desired functionality written in the user's language. By using a common cadence and synchronizing the iteration, teams are adjusted to a series of fixed length iterations to ensure that the entire system repeats itself. Teams use ScrumKSP or Kanban to deliver high-quality systems, which routinely produce a system demo every two weeks. This ensures that all ART teams create an integrated and tested system, which stakeholders can evaluate and respond to it to quick feedback. Each team has five to nine members and includes all the roles needed to build a quality increase in value in every iteration. The roles of ScrumKSP include a scrum master, a product owner, dedicated individual contributions, and all the experts on the subject for whom the team needs to deliver the value. The role of the Kanban team is less strictly defined, although many SAFe Kanban teams also implement ScrumKSP roles ("Team Level", 2017).

Before realizing the benefits of SAFe, organizations must adopt Lean-Agile way of thinking and understand and apply Lean-Agile principles, then identify value flows and Agile Release Trains (ART), implement Lean-Agile portfolio, build quality, and afterwards establish mechanisms for continuous delivery of values and DevOps. The Figure 3 shows the steps in the implementation of SAFe ("SAFe Implementation Roadmap", 2017).

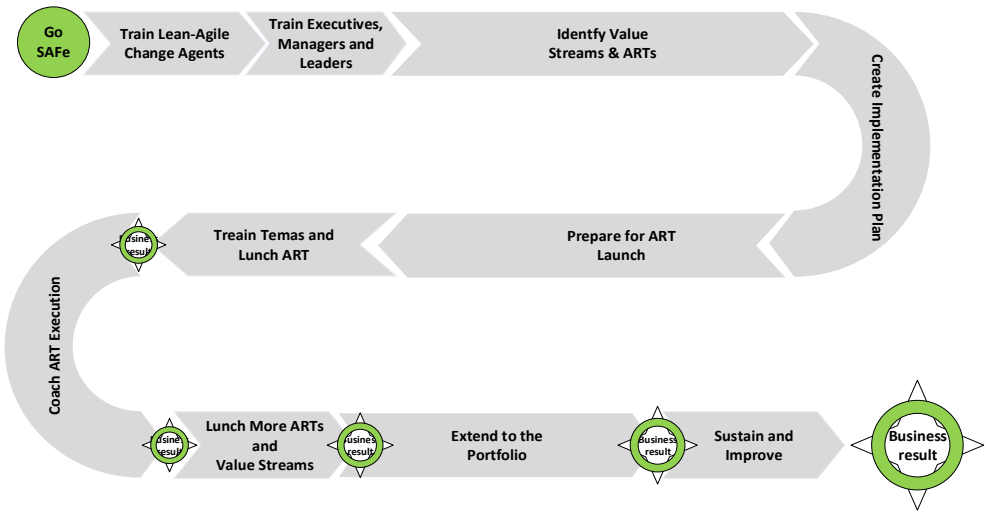

Figure 4: SAFe Implementation

Implementing of the changes, which are necessary to achieve Lean-Agile technology in an enterprise, is a significant challenge for most organizations. Implementation of Lean-Agile thinking and understanding, and applying Lean-Agile principles as well as effective implementation of SAFe in practice leads to e-business improvement. An appropriate culture must also be developed. Although SAFe knowledge is accessible to everyone, it does not define or prescribe the process of organizational change management, which is usually required for successful application-transformation. This is left to be determined by the company, because only the company knows its specific context, and the company must carry out the transformation.

Although there are no identical adoptions and it is rarely to have a perfectly sequential implementation step by step in any company, the best results are achieved if they follow a path similar to that one shown in Figure 3. Successful implementation includes the following 12 steps ("SAFe Implementation Roadmap", 2017):

- Achievement of the turning point
- Train Lean-Agile Change Agents
- Train executives, managers, and leaders
- Creation of the Lean-Agile Center of Excellence

- Identifying the flows of values and ART
- Creating an implementation plan
- Preparations for ART launch
- Training teams and launching ART
- Training of ART exercises
- Launching more ART and value streams
- Portfolio expansion
- Maintenance and improvement

Many companies have already gone through this path, and lessons learnt have become more and more available. Based on learning from hundreds of SAFe implementations, Scaled Agile, Inc. as the founder of SAFe, developed the basic implementation form SAFe 1-2-3 (Figure 4) for the successful adoption of SAFe. The form provides a simple roadmap, which helps to align with a common implementation strategy ("Implementing 1-2-3", 2016).

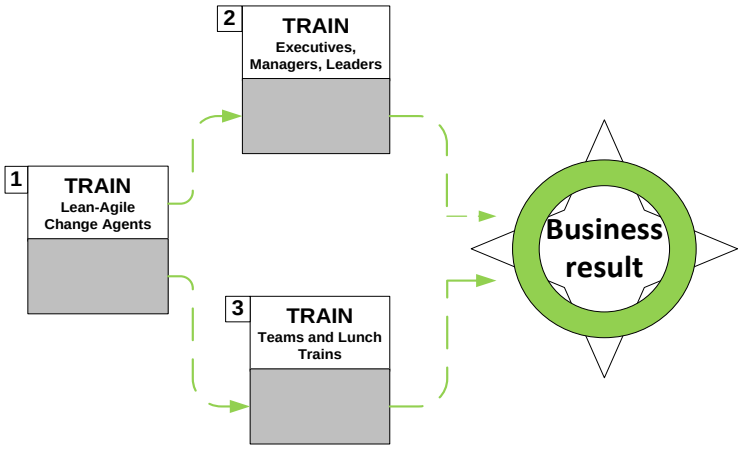

Figure 5: SAFe Implementation Strategy

3. SAFE RISK MANAGEMENT

The successful introduction of agile techniques at the project level is not the only challenge in this venture. Effective integration into e-business processes at a higher organizational level represents an additional risk in this process. The risk is part of our lives. In a rapidly developing world, the risks we need to manage develop rapidly too. They must be managed in order to minimize their threats and to maximize their potential.

Risk management involves understanding, analyzing and addressing risks in order to achieve the goals of organization. Therefore, risk management must be proportional to the complexity and to the type of organization ("MSF Risk Management Discipline", 2002).

The ideal solution for risk management at three levels introduced by SAFe, the level of a team, programs, and portfolios, does not exist. However, the categorization of risk is necessary for the proper treatment.

The majority of experts agree to manage risk at the code level at the team level during the Program of Increment Programming (Leffingwell, 2016). Higher-level risks (project or program) with potential to affect the entire Agile Release Train (ART) should be escalated to the level of the program. Teams do not have to analyze or to take into account the repeating risk, as all risks once occurred will be identified, listed, and planned to mitigate at the appropriate level. (Although there may be some risks at the portfolio level, managing them should be covered by managing the project portfolio of the organization or PPM).

A widely used risk mitigation tool within SAFe is ROAM board ("ROAM & Risk Management Under SAFe", 2017). It is utilized during PI planning to identify and analyze risks and problems. To ensure that all risks are covered, the aim of this technique is to Resolve, Own, Accept (by product management team), or to Mitigate (therefore acronym ROAM). Potential issues that are solved on the ROAM board at the team level are not transferred to the Program Panel at the program level. Reducing of the identified risks can follow the course similar to that in an agile project. The main advantage of using the ROAM table is that it ensures that all risks are covered - after a ROAM session; the work should be committed to solving all the identified problems in one way or another. Another advantage is that ROAM can simply be transferred to a shared online tool, facilitating collaboration between geographically distributed teams.

4. SAFE CHALLENGES

In the most companies, which are constantly innovative and expanding, the balance between costs and control, i.e., maintenance of high quality has to be provided. Enterprises usually have a complex structure necessary to produce a large number of products (and this number is constantly increasing). Without adjusting and increasing the number of employees, such required intensity or even imposed changes would lead to the collapse (Schwaber & Sutherland, 2016).
In these e-business oriented systems, the application of the SAFe methodology brings the necessary order, systematization and the results are always the best product delivered on time to the right place, to the right customer in the right quality and the right amount.

The SAFe methodology enables the use of a proven, public framework, with clearly defined roles and artifacts for applying the Lean and Agile methodology at the enterprises. SAFe's knowledge and tools are transparent and SAFe trainers are always available. The digitized program board allows process monitoring all the time and quick identifications on the control panel, i.e., whether progress is normal or unusual. Lean-Agile leaders point out managers to look at tasks or problems from a new perspective. Well-defined roles and terminology within SAFe are used as essential indicators for those new in the framework. If the changes are being implemented very quickly, they can represent a shock to employees. On the other hand, rapid integration has enabled people to participate in the Agile system. Employees are guided by trainers who consistently transmit the value of change, and help people accept their roles with a new way of working. It is important to establish an acceptable relationship between trainers and employees (Leffingwell, 2016). The implementation of SAFe increased transparency and visibility and as results, effectively identified errors, obstacles, weak tools and bad engineering habits are possible. Transparency is invaluable, everything is visible to everyone, communication and conversations are more valuable than monitoring indicators. SAFe forms a powerful community that keeps up with the ever-increasing growth rate of industry; it forms a system that can deliver more products without increasing the number of employees, and thus remains competitive.

Nevertheless, understanding and explaining agile methodology is not easy. Agility and speed of change leave the impression of a division of responses without one or more centralized authorities, which is a contradiction to the management methodologies that have been present throughout the business for decades, and not only in the IT industry.

However, this is not true. Agile methodologies offer more flexible and quicker workflows, methods that are easier to adapt to changes and new circumstances but require very strict precision, from the periods in which the divisions work to responsibilities between employees. They required the application of enormous knowledge and lifelong learning. Moreover, this kind of management is more complex than some of the previous ones. It requires greater involvement of all members of one system. It is particularly important to understand the application of these methodologies in e-business. One of the main forces of SAFe is - people. Before starting a professional life, human resources are formed at universities. Changes, speed, scalability, innovation, lifelong learning - all of these qualities in the 21st century have become an imperative. The question that arises is how to operate in such an environment? In addition, how to design young intellectuals to manage in turbulent and for sure challenging circumstances? These are the reasons why the education of young professionals should introduce learning about agile approaches. Moreover, the introduction of education on agile methodologies and their application is necessary, because it is an environment in which it will work.

5. CONCLUSION

The contribution of this paper is to systematize knowledge about SAFe, since it is a new framework, and that there is not much literature on this topic. The paper analyzes SAFe, highlighting the advantages of its application, but also its weakness. The main purpose of agile project management is to deliver products in a shorter period and to provide better quality for less money. This fits perfectly into the concept of e-business. By increasing the transparency and visibility of the company, it is easier to identify mistakes, obstacles, weak tools and bad engineering habits. Transparency is priceless and in SAFe everything is visible to everyone, and communication and conversations are more valuable than monitoring indicators. The Agile Manifesto says: "The most effective way of transmitting information within a development team is face-to-face communication." In SAFe, it leads to the next level with the planning of promotion programs, routine, “face to face” communication, with a standard agenda that includes a presentation of the business context and vision followed by a teamwork.

Agile should carry less risk than the traditional "waterfall" approach. It should help the project team in their joint work to do the job in the best way. Keys to success are contained in a communication, team dedication, strong leadership and good planning.

The results obtained with the use of SAFe are usually: 20 to 50% increase in productivity, more than 50% increases in quality and 30-75% is shortening the time of market entry (Yakyma, 2016). It also achieves a measurable increase in employee engagement and satisfaction of employers.

A representative example of the implementation of SAFe is Intel. Intel is one of the largest publicly released SAFe applications based on the number of ARTs. Intel has conducted training of 2000 employees within three months and by 2017. developed the Lean-Agile practice. Intel has built a strong community that speaks a common language. Intel's efforts are helping Lean-Agile to maintain a steady increase in the growth rate of the industry. Lean-Agile helps Intel to deliver more products without increasing the number of employees, so it can remain competitive and continue to follow the Moore's law.

From all written above, we can conclude that scaling is not easy, but it is worth the effort because the results are excellent.

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DESIGNING A COLLABORATIVE FILTERING RECOMMENDATION SYSTEM IN E-COMMERCE

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Abstract: *This paper discusses an approach for designing a collaborative filtering recommendation system within web stores. The main goal is to improve the level of conversion and increase customers attention and total sales by providing them with most relevant content and services. Data is collected from users activities within webshop: which products a user added, how many times the user entered the same product and total time spent on a product page. Based on collected user data it is possible to find most similar users and offer items that similar users were interested in. Further, we describe steps in designing recommendation system, architecture and possible application of the systems.*

Keywords*: Recommendation system, collaborative filtering, e-commerce*

1. INTRODUCTION

In modern e-commerce solutions, when it comes to optimization of conversion rate and increasing the customers' attention, only the most relevant content and services have to be delivered. Users expect to be provided with the exclusive content adapted to their needs and characteristics. However, this is quite complex and involves comprehensive approach including a variety of technologies, techniques, and concepts.

Accordingly, recommendation systems have been extremely important in last few years as they could be used in different areas, such as articles, social content, movies, books, news, and products as well. Recommendation systems have become an integral part of all the well-established online stores today. The main role of recommender systems is to search through a large volume of dynamically generated data in order to provide users with personalized content and services. They can especially be useful in e-commerce systems since the system is suggesting users which products user might be interested in and good recommendations can lead to a direct increase in sales.

This paper focuses on designing a recommendation system within an e-commerce solution, based on data collected through users' actions in a web store. The goal of the research is to investigate possibilities of using collaborative filtering techniques in order to improve conversion rate and results of content recommendation within web stores.

2. LITERATURE REVIEW

Recommendation systems have been in focus of many research papers. Most existing recommender systems use content-based or collaborative filtering methods or hybrid methods that combine both techniques (Aciar et al., 2007). The collaborative filtering approach to the recommendation is based on recommending items based on other similar users behavior (Balabanović & Shoham, 1997). Table 1 summarize approaches and examples from the literature.

All articles from Table 1 are based on using recommendation systems in different environments. Some of them are also based on e-commerce websites, but their main focus is data collected through sales and product ratings. Most of the researchers that use recommendation systems in e-commerce are focused on user data that is collected through sales or product reviews. This approach works well and it is already investigated. In this paper data collected from user actions on product pages are used. The benefit of this approach is that user actions from e-commerce websites are used, so there are much more data available for mining compared to a traditional approach, where only sales data or product reviews are tracked. It happens often that users browse through e-commerce websites and not buying on that website for various reasons (like for example price). But, those users can be used for collecting data and to learn more about visitors.

Table 1: Related literature overview

Context	Description
Book recommendation system (Tewari et al., 2014)	Combining features of content and collaborative filtering and association rule mining in order to recommend books to users.
Videos recommendation system (Deldjoo, et al. 2016)	Content-based recommender system for recommending videos based on extracted visual features of the video.
Recommendation systems in social networks (Wei et al., 2017)	Improving recommendation accuracy in a cold-start situation by using additional sources of information, such as friends relationships and user-generated tags.
Product recommendations from social networks data (Zhao et al., 2016)	Solution for a cold-start product recommendation, which aims to recommend products for e-commerce websites to users at social networking sites in "cold-start" situations.
Product recommendations theoretical approach (Wang & Zhang, 2013)	Proposed proportional modeling approach to the recommendation research field and a new opportunity model to explicitly incorporate time in an e-commerce recommender system.
Recommendation systems in B2C systems (Li & Karahanna, 2015)	Reviewing recommendation systems on B2C e-commerce systems. Identify gaps and future directions.
Personalized recommendations in B2C (Ji et al., 2004; Zhang & Jianxin, 2007)	Customer shopping model for B2C customers. Classification-based recommendation system for personalization in B2C e-commerce applications.
Recommendation systems effects on consumer beliefs / social context (Benlian et al., 2012; Weisberg, 2011)	Recommendation systems effects on effective and trusting dimensions of consumer beliefs. Relationship between past online purchases and purchasing intentions.
Recommendation system for e-commerce systems (Phi et al., 2016; Castro-Schez et al., 2011)	Focusing on the item-to-item and user-to-item recommenders.
Collaborative Filtering (Koren and Bell, 2015)	Improvements and recent progress of collaborative filtering methodology.
User-based collaborative filtering (Ma et al., 2015)	Revised the user-based collaborative filtering technique and proposed two recommendation approaches fusing user-generated tags and social relations.

3. DESIGNING A COLLABORATIVE FILTERING RECOMMENDATION SYSTEM IN E-COMMERCE

The goal of the research is to build an e-commerce recommendation system that uses users actions as the input. Further, the output of the system should be suggested products that the user is interested in. The recommendation system uses collaborative filtering where the system looks for similar users and based on that, the system recommends products that similar users were interested in.

Main user actions that were tracked are: which products user added, how many times the user entered the same product and total time spent on a product page.

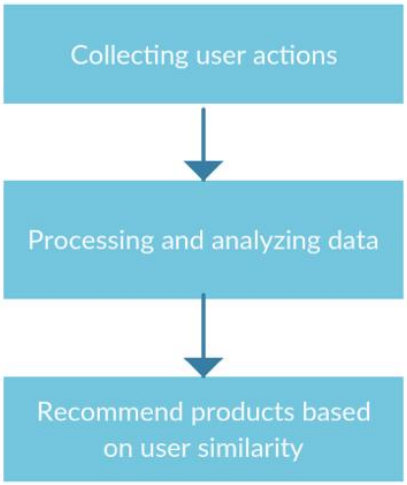

Figure 1: Recommendation system design

Figure 1. presents steps in the design of recommendation system: (i) collecting user actions, (ii) processing and analyzing data using Nearest Neighbors method, (iii) recommend products based on user similarity.

3.1. Collecting user actions

Collecting users actions data is a first step in building a recommendation system. Table 2 describes data collected from different users are shown. Part of the data is presented below in a way so it can be used for recommendation system.

Table 2: User behavior table

	User	Product	Time spent	Product clicks	Added to cart	Purchase
Case 0	1	1	38	2	1	1
Case 1	1	2	22	1	0	0
...	…	…	…	…	…	…
Case X	4	9	10	1	0	0

The fields represent collected user behavior data separated by the user, which is marked as a case. It is shown how many times each user clicked on a specific product and how much time the user spent on a product page. Also, it shows how many times each user added product to a cart and how many times user purchased a specific product.

3.2. Processing and analyzing data

Recommendation system method that is used is Nearest Neighbors. Nearest neighbor method principle is to find a predefined number of training samples closest in distance to the new point and predict the label from those. The distance is any metric measure - standard Euclidean distance is the most common choice. In this case ball, tree data structure is used, since that is optimized for a large amount of data comparing to K-dimensional Tree (Omohundro, 1985). A non-parametric procedure has been introduced by Fix and Hodges in pattern recognition literature as the voting k-nearest neighbor (k-NN) rule (Fix & Hodges, 1951). According to this rule, an unclassified sample is assigned to the class represented by a majority of its k nearest neighbors in the training set (Denoeux, 1995).

Using Nearest neighbor indices and distances for each record in object X (user behavior array) are printed. A part of the printout is shown on the following figure.

Table 3: Indices and distances for each element

Indices	Distances		
0 17 12	0.0	5.56776436	6.55743852
1 15 23	0.0	3.87298335	5.56776436
2 11 16	0.0	2.82842712	3.0
3 9 20	0.0	3.31662479	4.12310563
4 10 12	0.0	18.1934054	22.22611077
5 19 11	0.0	2.64575131	2.82842712
6 3 20	0.0	4.47213595	4.58257569
7 9 8	0.0	2.23606798	4.24264069
…			…
27 26 20	0.0	1.41421356	1.41421356

In the table above left column represents users ids in a list and right column represents how similar are those users. The nearest neighbor of each user is the user itself, at a distance of zero. The third and fourth elements are the elements with closest distances to the specific element. As we can see from the third row in the table above, user 1 is very similar to users 15 and 23. We can see in the fourth row that user 3 is also very similar to user 9.

When a new user comes to the e-commerce store, we have a situation of cold start problem. Many papers discuss on cold start items (items generated without knowledge about previous users' behavior). However, this is not within the scope of the paper.

3.3. Processing and analyzing data

Products are recommended to a current user based on calculation how similar is current user to other users that already visited e-commerce website. Accordingly, when a user *X* visits product *Y*, the system will take that as an input from user *X*. That input will be used to compare user *X* with other users in the system. The recommendation system is able to predict what other products user *X* might be interested in. Example recommendation that that system outputs like this: [7.68114575, 8.83176087, 9.53939201] -> [7, 9, 3].

The output that is shown above shows us how similar is user *X* with the other users in the system. As we can see in the example above a new user is the most similar with a user 7 (closest distance), a little less similar with a user 9 and after that to user 3.

Based on the example above, the system determines which users are similar to the current user and the system can choose products for the current user that similar users were interested in. If two users are similar and one of them added a product to the cart or purchased the item, we can also expect for the similar user to do the same. The recommendation system is showing all products that the most similar users purchased. If user *X* is the most similar to user 7 (as in the example above) then the recommendation system will show all items that user 7 purchased as recommended. In the current implementation, the recommendation system always uses only users who had made a purchase for comparison with other users (those users are the only ones that have a real value for the e-commerce system). The more data from users is collected, more correct a recommendation system will predict products that user *X* is interested in.

As mentioned above, this system can be implemented in a real-time e-commerce website. In order to implement there are few steps involved: (i) implement collecting user behavior data using JavaScript, (ii) send collected data to a web server, (iii) store data in the database, (v) fetch recommendations from recommendation system API call (v) render recommendations on the page. That is shown in the figure below.

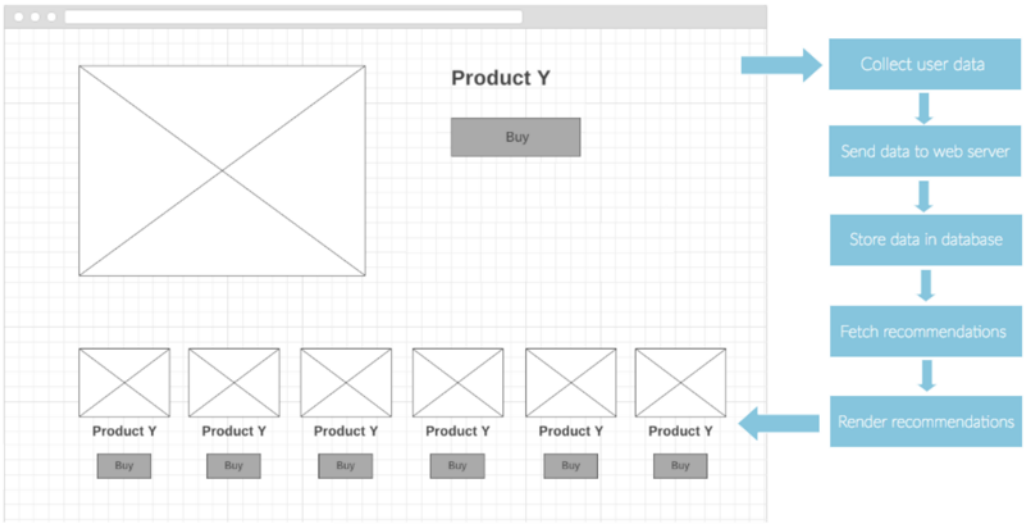

Figure 2: Recommendation system design

The developed system includes following software architecture elements: (i) HTML website, (ii) PHP server, (iii) database server and (iv) recommendation system server. HTML website is making a request to a PHP server (using JavaScript) and PHP server is getting user information from the database server. PHP server gets recommendations from recommendation system server. Communication between these entities is shown in Figure 3.

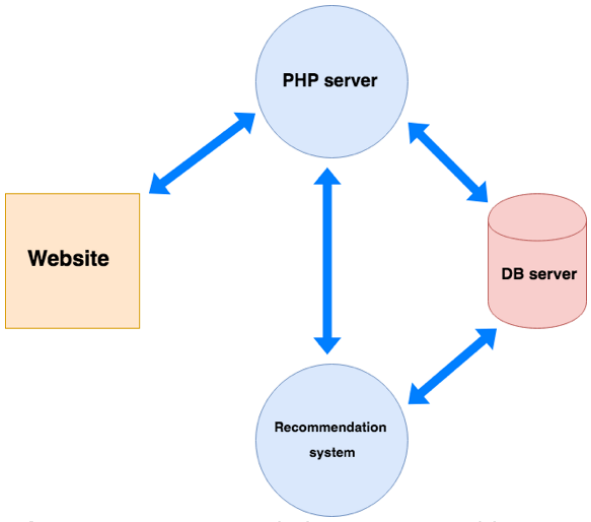

Figure 3: Recommendation system architecture

4. DISCUSSION

This system is different from the other recommenders in e-commerce systems (Benlian et al., 2012; Weisberg et al. 2011), because it tracks all data available from user behavior that can lead to better understanding what user might be interested in. The system main focus is not on using previous purchases from users. Instead, the main focus is on the helping user who hasn't yet made its purchase or new purchase is not related to old one. The scenario where the user purchases one item and comes again to purchase the similar item does not happen very often.

Nowadays, a lot of researchers integrate social media into e-commerce systems and use them for creating recommendations as users are enabled to log in using social media and like products with social buttons. In (Li et al., 2013) authors proposed a social recommender system that can generate personalized product recommendations based on preference similarity, recommendation trust, and social relations. Compared with traditional collaborative filtering approaches, advantages of the proposed mechanism is reflected in its comprehensive consideration of recommendation sources. This paper is not considering data from social networks. It is focused mainly on user behavior collected data.

Numerous studies have investigated recommendation systems as they play an important role in e-commerce websites since those systems increase sales and income for the shop owners. For example, (Lin, 2014) performed an empirical research that investigated to which extent recommendation systems increase sales within B2C platform in China market. He found out that user recommendations are more effective than system recommendations in driving product sales.

The main contribution of this paper is reflected in a proposed approach for recommendation systems in e-commerce websites focused on user behavior. Common recommendation systems for e-commerce websites use only sales as a parameter for recommending products. In implemented recommendation system complete user behavior is tracked. After finding a similarity between the current user and other users in the system, a recommendation system is able to predict in a real-time which products will be interesting for the current user.

We acknowledge that the proposed solution does have some limitations and can be improved. There are many different data that can be collected from a user behavior in order to find out how interested are users in the product, for example, user's social media interaction on pages. Also, product reviews and sales can be tracked together with users browsing data. In addition, time factor should be considered in users behavior, so only recent users actions should be considered. Below there is a list of advantages/disadvantages of the developed model:

Table 4: Advantages/disadvantages of the developed model

Advantages	**Disadvantages**
Real-time recommendations	Not considering the time factor
Focus on user behavior	Not considering social media interaction on pages
Does not require many data	Not considering product reviews and sales data
Recommendation based on similar users behaviour	Many user behavior data not tracked/mentioned
Ease of adding more user behavior parameters into the system	
Fast recommendations	

5. CONCLUSION

Recommendation systems are now used everywhere. All e-commerce platforms have some kind of recommended products lists. Most of those lists are purely based on product popularity, which actually represents a number of sales. Because of that, many e-commerce websites have a problem with products that used to be attractive to users, but they are not anymore. Those products are shown in popular products lists unless they are manually removed by e-commerce system administrator.

There are a lot of opportunities to add intelligence and personalization in every part of every system, creating experiences that seem like a friend that knows you, what you like, and what others like and understands what options are out there for you. Recommendations are discovery, offering surprise and delight with what they help uncover for you. Every interaction should be a recommendation (Wei, et al., 2017, Smith and Linden, 2017). Recommendation systems do not consider users behavior and how much time a user spends on the specific page and how many times the user enters pages. Also, it is important to know how many times user added product to the cart, even if a purchase was not been made. In the time when many retailers sell a large number of goods online, it is important to use recommendation systems that will help users navigate through the site and find what they look for.

The expected future of recommendation systems in e-commerce is to track complete users behavior and make some conclusions about the user. Based on that, recommend specific items to the user. Also, in the future, we will probably see increased usage of recommendation systems, not just for some products list as it is used now. In the future, complete e-commerce systems will be adjusted based on the users' behavior and expectations.

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OVERVIEW OF TRAVEL DEMAND FORECASTING METHODS USING SEARCH ENGINE QUERIES

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Abstract: *Travel demand was always very unpredictable, depending on many factors. Up until the emergence of several search engines, it was very difficult to forecast travel demand. Demand prediction is important to hotel management teams that can use produced information to adapt room prices and impact total revenue. Search engines Google and Baidu became an integral part of tourist research, as search queries about particular destination became key performance indicators. Since there are no available papers that cover all present methodologies for demand forecasting, this paper intents to fill this gap. This paper assesses relevant methods that use search queries for demand fluctuation prediction. Using econometric models such as ARMA, ADL, TVP and VAR, it is shown that there is a strong relationship between queries and actual demand. There are several hundreds of potential queries that can be used as input for the models, and picking those with highest predictive power is not easy. It is shown that search engine data has strong predictive power if appropriate queries are used as input for predictive models. Successful predictions will lead to better price management and in the end higher revenue for hotel businesses.*

Keywords*: demand forecasting, dynamic pricing, revenue management*

1. INTRODUCTION

The global travel industry gross bookings reached $1.6 trillion in 2017, making it one of the largest and fastest growing sectors in the world. Factoring in indirect economic contributions, travel and tourism now accounts for a staggering 10.2 percent of global GDP. This continuous growth that was seen from 2010. onwards, is underpinned by several key factors mutual for all global markets and many other factors bound locally. Although some industry experts are pointing out concerns about the high growth, trying to indicate cyclical history of the industry and potential downturn, there are more of those who are bullish on the industry. There are some key indicators of strong outlook on the travel industry that are not connected to the economic dynamics and point to the strong growth in the long run. Revenue management is one part of the hotel business that can be improved using available data and mathematical approaches that will yield improvement in the decision-making. In order to achieve improvements, we must first recognize other factors influencing total revenue.

The first and most important factor is the demand. Currently, very few hotel chains in the world use some sort of demand forecasting that helps them define the price for the future periods. There is high variability in demand in the short-term as well as long-term. There are many factors influencing demand level such as: economic environment, transportation availability, one-off events etc. If hotel management could predict the rise in demand in the next week, they could raise the price of available rooms and still sell them. There is surplus coming from this intelligent decision-making that can be captured. There are several papers dedicated to demand forecasting in travel (Yang X, et al.,2014), (Bing et al., 2012). In the next chapter we will discuss some of the methods, their strengths, limitations and underlying assumptions.

Second important factor is the offer of the competitors. In travel and hospitality, there is a fixed amount of demand for a certain period. Customers are getting informed online and choose the place where they want to stay, based on the supply. A customer would naturally choose the cheaper option if the services of both options are identical. Hotel businesses must identify the characteristics they offer and find their respective competitors who offer same or similar services and compete with them for winning over customers. In the current environment, most businesses use traditional approaches to mapping out their competitors and occasionally following their actions. There is no standardized approach to dealing with changing prices of the competitors and making informed decisions based on them. The last argument creates motivation for future research.

There are several technological trends present in the hotel industry which was part of the research conducted in order to assess impact of technology on the industry. Reserch (Daniel Guttentag, 2013) was conducted on a new business model proposed by Airbnb, which is the first disruptive use of technology in the hotel industry. It represents an innovative accommodation product that has shifted perceptions of hospitality throughout the hotel industry. While Airbnb remains a topic of significant attention within the

sector, there is little understanding of the degree to which it is used as a hotel substitute, or how Airbnb guests view the service relative to hotels. This study offers important insight into these questions by showing that many Airbnb guests use the service in place of a hotel, and especially mid-range hotels. Secondly, IATA statistical report shows 10% increase in number of passengers carried by low-cost carriers in 2017. compared to 2016. Increase in all other price categories were below 5% for the same compared periods. Also, most of the traditional airline metrics such as Revenue passenger killometers (RPK), Available Seat-Kilometres (ASK) and load factor, all show higher growth than other price categories. This indicates strong overall growth in low-cost segment of air flights. Thirdly, (De Pelsmacker P., Tilburg S., & Holthof C., 2018) is a research on digital marketing efforts and results of over 200 hotels in Belgium. Authors focused on eCRM and concluded that online reviews, TripAdvisor profile nurturing, responsive digital footprint all affected room occupancy favorably. This indicates relevance of digital marketing and customer relationship management.

2. METHODOLOGY

Purpose of (Bing Pan et al., 2012) was to determine if search query volume was useful in forecasting demand for hotel rooms. The authors used search volume data on five related queries to predict demand for hotel rooms in a specific tourist city and employed three autoregressive moving-average (ARMA) family models and created their ARMAX counterparts involving Google search data to evaluate the usefulness of these data. The authors also evaluated three widely used econometric models – ADL, TVP, and VAR – for comparison.

ARMA models

ARMA model takes the form:

$$lny_t = \mu + \sum_{i=1}^{p} \varphi_i lny_{t-i} + \varepsilon_t + \sum_{i=1}^{q} \theta_i \varepsilon_{t-i} \quad (3)$$

AR model is a specific for of the (3) where q = 0:
:

$$lny_t = \mu + \sum_{i=1}^{p} \varphi_i lny_{t-i} + \varepsilon_t \quad (4)$$

ARIMA has the form:

$$\Delta^d lny_t = \mu + \sum_{i=1}^{p} \varphi_i \Delta^d lny_{t-i} + \varepsilon_t + \sum_{i=1}^{q} \theta_i \varepsilon_{t-i} \quad (5)$$

ADL model

ADL model regresses lagged depended variables to arrive a at current predicted value, models derived and used in this study has the form of:

$$lny_t = \mu + \sum_{i=1}^{p} \varphi_i lny_{t-i} + \sum_{i=1}^{5} \sum_{j=0}^{p} \alpha_{ij} ln\, x_{i,t-1} + \varepsilon_t \quad (6)$$

TVP model

TVP model used in this study established a relationship between the demand for hotel rooms and the Google search data. The model includes measurement and transition equations:

$$lny_t = \alpha_{0t} + \sum_{i=1}^{5} \alpha_{it} lnx_{it} + \varepsilon_t \quad (7)$$

$$\alpha_{jt} = \alpha_{j,t-1} + \mu_{jt} \text{ (j = 0,…,5)} \quad (8)$$

VAR model

VAR model differs from others in the sense that it treats variables and endogenous, which results in capturing the dynamic nature of demand. It is expressed as:

$$Y_t = C + \sum_{i=0}^{p} A_i Y_{t-i} + e_t \quad (9)$$

All three ARMAX models consistently outperformed their ARMA counterparts, validating the value of search volume data in facilitating the accurate prediction of demand for hotel rooms. The data used was composed of 5 different keywords labeled as room searches focusing on one city particularly. After the models were used, authors tested their accuracy using mean absolute percentage error (MAPE) and root mean square percentage error (RMSPE):

$$MAPE = \frac{1}{m}\sum_{t=1}^{m}\left(\frac{|\hat{y}_t - y_t|}{y_t}\right) \quad (10)$$

$$RMSPE = \sqrt{\frac{1}{m}\sum_{t=1}^{m}\left(\frac{\hat{y}_t - y_t}{y_t}\right)^2} \quad (11)$$

these two measures have been applied to evaluate the forecasting performance of tourism demand models (Song and Witt, 2006; Vu and Turner, 2006).

Authors made the point that web search improves predicting accuracy so in our own research we can assume relevancy of Google search data in some degree. Also, fellow colleagues developed a simple but powerful model that will be a starting point for further research, taking into account some of the limitations stated in their paper. Only 5 keywords were used in the model and since travel involves complicated decision-making, including more queries in the model would likely increase forecasting accuracy.

3. METHOD FOR CHOOSING QUERIES

Proceeding in our research on demand forecasting models, we came across interesting paper that had approach to forecasting which eliminated limitations of the 5 query approach (Yang X, et al.,2014) in their paper “Forecasting Chinese tourist volume with search engine data” had similar approach but they invested more effort into selecting relevant queries. Using iterative approach, they calculated the correlation coefficient between Hainan monthly visitor volumes and each of the search queries with different lag periods. Authors chose search queries that had correlation coefficient above the threshold of 0.76 arriving at 10 Google search queries and 25 Baidu queries. Threshold was set to optimize accuracy-parsimony trade-off. Using this approach, authors could identify an interesting pattern of Chinese tourists. Lags with significant correlations were in the range of 0-6 meaning tourists do not search for travel data more than 6 months before the trip. More detailed analysis showed that most Chinese visitors to Hainan first searched travel agent information, about six months before the trip. Then they searched for flight information four months before the trip, and finally one month before departure, they would look up weather and shopping opportunities. This confirmed the assumption that decision-making of travelers follow a pattern which was recognized using lags and search queries.

Yang X., Pan B., Evans J.A., & Lv B. (2014) used co-integration analysis of search index and destination visitors. Using a shift and sum method, they created a composite index which they compared to destination visitor index.

$$logT_{t1} = c_0 + \beta_1 logT_{t1}(-12) + u_t \quad (12)$$

$$logT_{t1} = c_0 + \beta_1 logGl_{t1} + u_t \quad (13)$$

$$logT_{t1} = c_0 + \beta_1 logBl_{t1} + u_t \quad (14)$$

Formulas 12-14 represent a model where T_{t1} is predicted value, visitor volume estimate,Gl_{t1}, is search index from Google and $Bl_{t1}$is Baidu search index .

To conclude, (Yang X, et al.,2014) reviewed present models for predicting visitor volume, but most importantly contributed to the field in two ways. Firstly, it was proven that Local search engine Baidu has more predictive power in Chinese visitor forecasting than Google, which can be attributed to the cultural

factors. The second contribution is the approach for selecting keywords that have highest predictive power. This approach lays the ground for future research in this field. In terms of application, the paper provides a new way of predicting tourist volumes for hotel managers and policy makers. There is another application of the model, where managers can use it to predict the increase in tourist volume and use this as the basis for benchmarking of their own performance, for example if the model shows 15% increase in volume and the certain unit has 5% increase, it shows weak performance. Authors stated this last application in their paper but there are some market factors which have significant power over variations. Model is not taking into account purchasing power, behavior and preferences of the customers, thus out of 15% of volume increase, there could be 12% coming from financially strong customers which are simply not using perhaps hostels, making 3% increase in hostel visitors volume justified.

As a next step, authors propose using tweets, blog posts, and social media posts to be used in the analysis. The combined power of several data sources could improve prediction accuracy which will lead to better tourism management. This will be taken as input for future research.

4. CONCLUSION

The travel industry is taking a big swing in recent years, increasing to 10.2 percent of global GDP in 2017. Growth is stable since 2010. and even though there are authors who alarm about industry's cyclical nature, there are more of those who have a positive outlook on the future years. This high growth combined with new technologies created every day and increased amount of data in all of the sectors of travel, are leading to increased interests in the development of new business practices and techniques that can affect some parts of core decision making and increase revenues and bottom-line. Even though many sectors of the travel industry are growing and showing endless possibilities for data scientists and data engineers, we focused on hotel businesses for one simple reason and that is, availability of domain knowledge through personal contacts. There are several identified trends in the hotel industry that are changing it significantly. This paper recognized several of them. Innovative business model of Airbnb, eCRM emergence and intense growth of low-cost airline flights which is driving low-cost lodging revenues. All these trends indicate high presence of tech-related innovations thus making future of the industry depending on technological development, which motivated us to investigate new ways of improving businesses in the travel industry using technology. Hotels have a simple business model to begin with, but a very complicated decision-making if there is an outreach for good revenue optimization. Since hotels are of fixed location, they are limited by the demand for lodging in their destination. Naturally, if hotels could predict future demand, they could modify their room prices (increase them) and still sell them. This can lead to increased revenue and overall profitability since cost factor is not affected by the price. There are several fields of application of intelligent systems and algorithms that improve hotel businesses. In the early 80s focus was on revenue optimization techniques which were based on stochastic models. Later, with more data present, the focus was shifted to forecasting models. With the rise of search engines such as Google and Baidu, foundations for extremely powerful models were laid. Several authors developed linear models that used search engine queries and analyze time-series data to arrive at fairly accurate forecasting models. In our assessment of such models, we focused firstly (Bing Pan et al., 2012) who used ARMA, ARIMA, ARMAX and three econometric models ADL, TVP and VAR to test if search queries are improving model accuracy. Research showed that query data is improving model accuracy which leads to the conclusion that data provides fine information about the decision-making process of travelers. There were some limitations in this approach. Authors used only 5 queries as input for the model, which is just a part of all the queries used by travelers. Second paper we assessed (Yang X, et al.,2014) used a structured approach based on correlations testing to determine search queries relevant to predictions. Besides identifying key queries, authors could explain lags between queries and travel date and formulate logical decision-making of travelers. Base model for prediction was index based co-integration analysis which resulted in accurate predictions. Final contribution of this particular research is benchmarking application where management can compare predicted demand increase and actual sales increase for the period to arrive at the conclusion about their performance relative to the average. By assessing some of the models present, we have laid foundations for future research in the field of travel.

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FRAMEWORK FOR VERIFYING DOCUMENTS ON THE BLOCKCHAIN

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Abstract: *Tampered documents can cause irreparable damage to governments and businesses. It can be impossible to determine how the document has been tampered, opening up the whole system for large losses due to fraud. Mitigating document fraud and document tampering should be a top priority for any business system. We propose a framework which can be used to keep track of all document changes, while at the same time allowing verification of documents across a distributed system. This eliminates document fraud and document tampering by providing an easy way to perform document verification among all users of the framework. The framework is based on cryptographic hashes and blockchain for persistence. Each hash is mapped to a physical document stored inside a document repository. If a document's hash isn't present on the framework's blockchain, it has been tampered and can be disregarded. Our framework provides a starting point for enterprise document verification based on known blockchain principles and best cryptographic practices.*

Keywords*: blockchain, authenticity, verification, document management*

1. INTRODUCTION

Main benefit in the usage of paper documents was the ability to easily verify them and check to see if they have been tampered. Archival purposes were also much simpler due to the way documents could be replicated by hand or printing machines. In some occasions, it would be necessary to verify the authenticity of the copy. During the copying process, either by hand or by machine, it is easier to tamper the original document. The verification process was performed by an authorized body, either appointed by the government or by the company, depending on the document type. Documents were archived in physical locations, so that they could be retrieved and cross-referenced if needed.

With the advent of digital technologies, new ways to prove their authenticity needed to be created. Digital documents could no longer be easily verified and authenticated. The ability to tamper them even after they have been created has been improved with the usage of computers. One approach to solve this issue was to keep double copies of the documents – either both double digital, with one document kept at a secure location, or having paper copies of each digital copy. Either way can prove to be resource intensive, as well as not efficient or environmentally unfriendly. Archival of digital documents can also prove to be a problem, since digital storage devices can fail earlier than paper, destroying the archived data.

By the utilization of cryptographic hash functions which use the documents as input we can keep track of different document versions safely. A cryptographic hash function is a one-way transformation which produces data depending on the input (Menezes, van Oorschot, & Vanstone, 1996). Each document change produces a new hash, thus eliminating the tampering process without amending the original document. The framework is document agnostic, allowing to store any kind of documents which can be successfully verified using cryptographic hashes.

The process of amending original document allows us to perform changes on the original document while keeping track of its changes. Patches are signed off by authorized users before being committed to the database. Each authorized user contains an asymmetric cryptographic key pair (Menezes, van Oorschot, & Vanstone, 1996) which can be used for safe sign offs and identity verification. Signing them off allows us to keep track of document integrity throughout its lifecycle, while at the same time preventing future tampering in case of signing off without approved cryptographic keys.

Document and patch storage needs to be safe from tamper to prevent loss. In case of loss, no documents can be verified. Usage of blockchain combined with document repositories can minimize tamper and improve overall security of the document verification system.

Using the blockchain for storage of document and patch signatures provides a linear read-only access to previous records. Blockchain is a linear distributed database where entries (blocks) are added to it after a

consensus between blockchain users has been reached (Nakamoto, 2008). Benefits of linear access are fast access to the data and the ability to perform advanced analysis on the data, such as blockchain filtering and rotation (Zivadinovic, 2017).

Storing whole documents and their patches on the blockchain would prove to be cumbersome due to their size (Lunde, 2012). Because of performance issues, documents and patches are kept inside document repositories. Document repositories represent file storage devices where files representing documents and patches are stored (Green, 1993). Each one of them can be used as input to produce a hash value. The resulting hash value is used for future blockchain operations.

The framework shown in the following chapters should be treated as a proof of concept and a starting point for a complete implementation, not as a complete solution.

First two sections, "Existing document verification systems" and "Blockchain operations" are concerned with the overall review of current document verification blockchain solutions, as well as their core architecture.

The "Document verification framework structure" section applies the presented findings from previous two sections with the technical architecture and choices made during the development of this document verification system.

Use cases for the presented document verification system are presented in the fourth section. Two use cases are presented, one focused on citizen and government usage, while the second one is focused on company accountability and its inventory keeping of government regulated goods.

Last chapter, “Conclusion”, represents an overall impact of the presented system.

2. EXISTING DOCUMENT VERIFICATION SYSTEMS

One of the first works on the topic of blockchain and document verification is a paper written by Aravind Ramachandran and Dr. Murat Kantarcioglu (Ramachandran & Kantarcioglu, 2017) using Ethereum smart contracts (Wood) and Open Provenance Model (Moreau, Freire, Futrelle, McGrath, Myers, & Paulson) for tracking and correlating data. Their work is based on the interconnectivity between data for scientific research and keeping it safe from fraud, such as data fabrication. Results from this paper can be further refined and applied to all document management and document verification systems where we have documents consisting of multiple legs, such as multiple forms required for a single request.

Discovered document verification systems are mostly concerned with verifying identification documents. Governments of some countries, such as Australia (Government of Australia).One common thing between all reviewed document verification systems is that none of them openly provides the business process insights concerning verification. Another one worth mentioning is the Trudatum (Coinfirm Ltd., 2018) blockchain file verification service.

Gemalto offers its *Gemalto ID Verification* solution to perform document verification (Gemalto). Their system works with different types of user identification documents, such as passports, visas and ID cards. Document verification is performed upon a centralized database of templates. The procedure utilized by Gemalto is called *“Know Your Customer”* (KYC) to combat identity or financial fraud, as well as comply with international regulations. Its main usage is in government entities and large private companies (Gemalto).

Another company providing document verification is *Jumio* with its product *Netverify* Document Verification (Netverify). Similar to *Gemalto ID Verification*, *Jumio* provides the end user with the means to acquire and verify identification documents. *Netverify* Document Verification consists of the backend system and the mobile application utilizing different algorithms to perform data gathering from a document photograph. An additional benefit is masking of credit card numbers and other sensitive information, which is a prerequisite for PCI compliance (Jumio).

The Australian government provides a document verification system called *Document Verification Service* (Government of Australia) which allows different legal entities (such as companies) to check if the provided identification documents are valid and if there are additional government records connected to them. This system can only be used with Australian government issued documents and can provide several results concerning their status:

- Matched
- Not matched
- Document invalid or not electronically captured

Resulting data can be used by the legal entity to determine further identification methods, if needed.

Trudatum is a new software solution specifically made to work with files and documents. Their system works by leveraging the blockchain for file signing and verification. Trudatum is based on proprietary technology and at the time of writing, their services aren't available to the public, even though they have a successful pilot project behind them (Biggs, 2018).

3. BLOCKCHAIN OPERATIONS

Addition and modification operations represent the basis of the methodology used to form blocks of the blockchain. Even though the focus of this paper is on document verification, the presented operations are required to form a complete picture of the methodology used to verify documents on the blockchain.

Request acceptance by the blockchain means that the issued request has been propagated in full through the network utilizing the blockchain. The process of adding document hashes presents a fundamental step in the blockchain document verification methodology. Without it, we are unable to extend the blockchain with new document hash entries, thus being unable to verify the documents in question.

The process to add new document hashes to the blockchain is the following:

1. Create a document
2. Add it to the document repository
3. Generate its hash value
4. Send a request containing the necessary information to the blockchain endpoint
5. Parse the response from the blockchain endpoint

The request contains the public key of the author signing off the document and the document's hash value. On a successful response, we have confirmation that the document is now being tracked on the blockchain.

Modifying documents already tracked by the blockchain allows us to make amends to them. Amending documents is more space efficient since we track only the changes on the document, not the whole new document. When modifying, we use the blockchain to track the hash value of the patch which is applied to the document. A patch represents a set of changes needed to evolve a document from one state to another.

Tracking document patches on the blockchain is similar to adding document hashes:

1. Modify the document locally
2. Generate a patch from the changes
3. Generate its hash value
4. Add the patch to the repository
5. Send a request containing the necessary information to the blockchain endpoint
6. Parse the response from the blockchain endpoint

The request needed to publish a patch to the blockchain contains the public key of the author which signed off the patch, the hash value of a document we wish to patch, the hash value of the document with the previous patch applied (if it exists) and the hash value of the document with the latest patch we have applied.

If the system returns a successful response, the patch is now active and the parent document has been amended. Previous versions of the document in question are now invalid – only the document with the applied patches up to the last one is valid.

The list of patches which need to be applied to transform the document to the latest state can be extracted from the blockchain by following the parent references of requests. This process is called document restoration. It is possible in all cases of modification, except in the cases of deletion where all file formats, when empty, produce the same hashed value.

Deleting documents is the same as modifying them. In case of deletion, patch files contain the necessary data which is used to delete their content. The original document location on the repository is unchanged. Only its content becomes blank. Deleting the document from the repository is out of scope, but can be extended by adding checks for its presence.

When the document's content has been deleted, depending on the file format of the document, it can be possible to recreate it by following the blockchain backwards from the deletion patch.

Document verification, the core of this paper, is performed opposite of the process of adding document hashes to the blockchain:

1. Generate the hash value for a document you wish to verify
2. Send a verification request to the blockchain endpoint which contains the hash value
3. Parse the response from the blockchain endpoint

The parsed response can be either positive or negative. In case of a positive response, we have proof that the document we are verifying exists in the blockchain and that it hasn't been amended by patches.

4. DOCUMENT VERIFICATION FRAMEWORK STRUCTURE

The overall system consists of several components:

1. Blockchain
2. Blockchain endpoint
3. Document repository

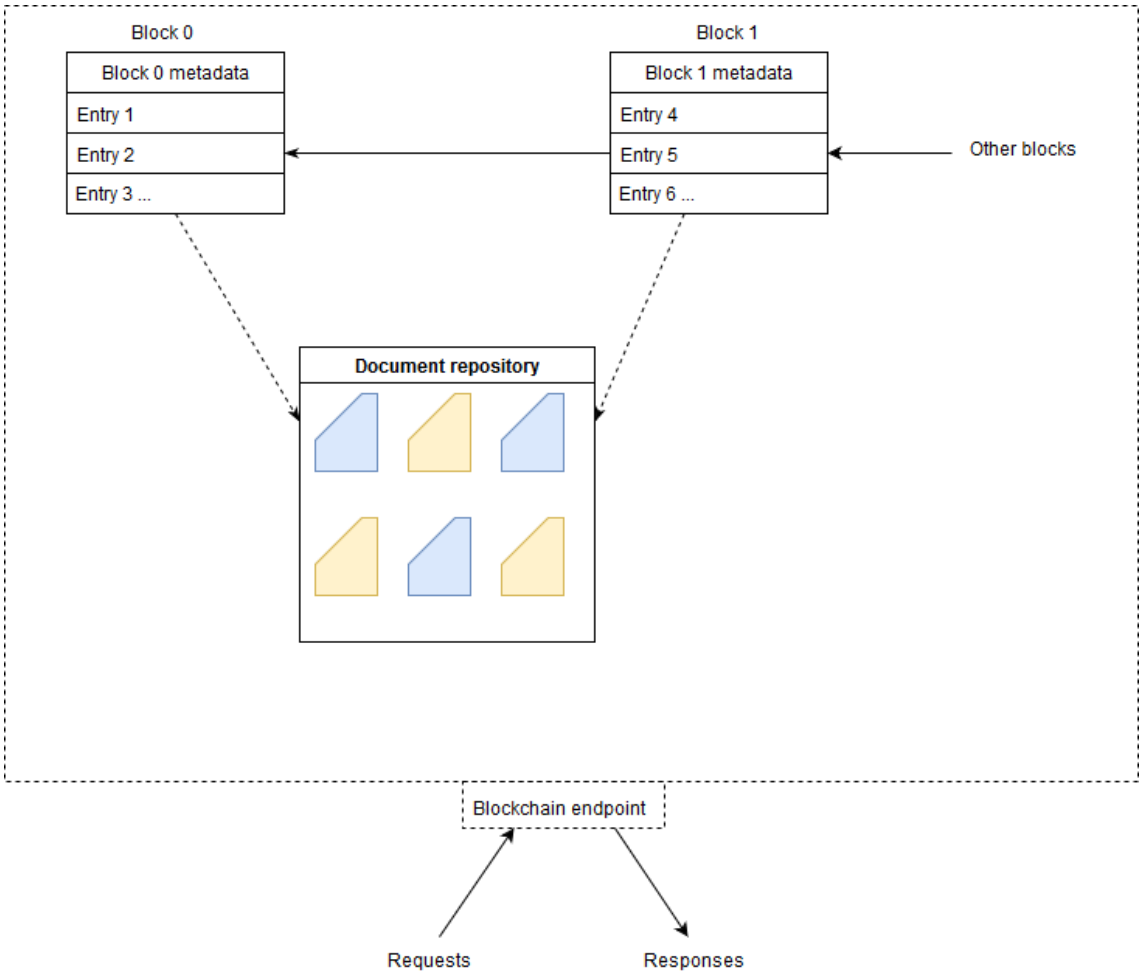

Diagram 1: Framework architecture

As mentioned in the introduction, blockchain is a linear distributed database where entries (blocks) are added to it after a consensus between blockchain users has been reached. Blockchain is distributed across multiple nodes. A node is a computer running an instance of the software used to manage the blockchain. All nodes have the same copies of the blockchain. Nodes are denoted by the blockchain itself, since they all contain copies of it.

Blockchain configuration is stored in the block metadata. The metadata represents an index into the blockchain, which allows search and filtering of data. Metadata is represented by the following data structure:

```
{
 id: 0,
 parent: null,
 time: ["2018-02-12T17:03:12+00:00","2018-02-12T18:03:12+00:00”]
 count: 3
}
```

Image 1 : Block metadata format

Where *id* is the number of the block in the blockchain sequence, *parent* represents the previous block *id* in the blockchain, *time* represents an array of start and end time of entries which the block contains and *count* denotes the number of entries inside the current block.

In order to add new blocks and entries to the blockchain, majority of nodes needs to perform a consensus vote in order to determine whether the data will be added or not. The consensus vote depends on the consensus algorithm implemented, but for simplicity, we are assuming that the consensus is reached when 50% plus one node approve the addition of data. On successful consensus vote, the incoming request gets added to the current active block as an entry. The current active block is determined by the time period it represents.

Positive consensus vote is achieved when the incoming data to the node gets evaluated by the software used to manage the blockchain. The evaluation is done across different criteria, depending on the application. When evaluation has been completed, the resulting data is propagated across the network of nodes.

Backbone of the communication between nodes is handled by the blockchain endpoint. Blockchain endpoint is a set of network configurations and infrastructure connecting blockchain nodes between each other and allowing access to the blockchain from outside. The end user using the blockchain would need to access only the blockchain endpoint, without having knowledge of the internal structure. The request would get routed to all nodes of the system and wait for their response.

Document repository represent file storage devices where files representing documents and patches are stored**.** In the diagram above, blue files represent documents, while yellow files represent patches. Documents and patches do not need to alternate between each other, as shown in the picture. Entries contain references to the hash values of documents and patches.

Patches should conform to the *Unix diff* unified format (Free Software Foundation). This allows a standardized way to apply patches to documents, as well as makes the patches human readable for inspection.

Entries represent parsed requests which have been consented by the nodes and written into the blockchain. An example entry is shown below:

```
{
 author: "someOtherAuthor",
 previous: "hashOfDocument",
 current: "hashOfPatch"
}
```

Image 2 : Entry format

Where the field *author* represents the sign-off public key of the author, *previous* points to the hash value of the last patch (if it exists) and *current* is the actual hash value of the document or patch.

The diagram below represents mapping between the document repository and the blockchain. It is visible that the entries inside the blockchain contain all the necessary data to identify and reference to documents inside the document repository.

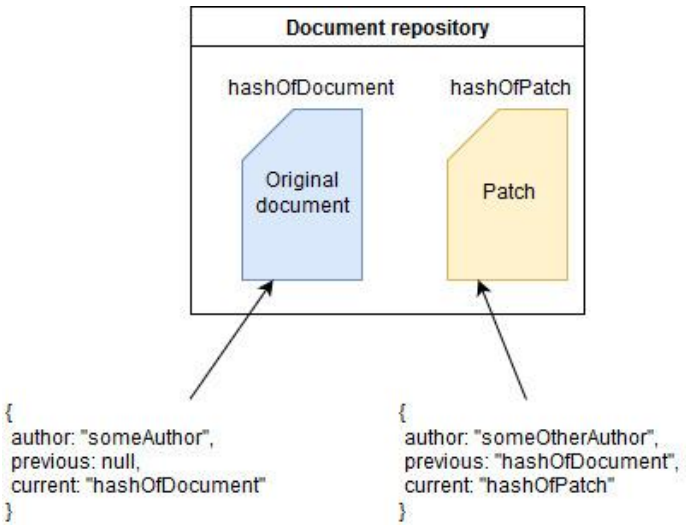

Diagram 2 : Blockchain and document repository mapping

Hash values used throughout this paper are assumed that they have been generated by the *SHA256* algorithm, while the cryptographic key pairs are assumed that they are based on the *RSA* cryptosystem with 2048 bit key length. The sign-off key is the public key of the key pair. Author verification is performed by choosing some data which is going to be used as the base line. Encrypting it by the private key in the entry and decrypting it by the author's private key should prove the public key's affiliation to the author – but only if the resulting decrypted data is the same as the input.

5. USE CASES

5.1. E-government

Having a distributed index of documents which cannot be tampered by any way without notifying the system of changes can prove to be the backbone of e-government. This would benefit both the citizens and the clerks of the country where its implemented.

The citizens would have an open way to check the validity of their documents by simply issuing the requests to the e-government blockchain and retrieving a positive or a negative response from the system.

On the government side, government procedures which monitor the blockchain can perform real-time updates when the documentation becomes expired. One concrete example is the driving license: in case of its expiration, the system would publish a patch request that invalidates the driving license in some way (such as setting a flag in the document). This, in turn, would amend the original driving license the citizen wants to verify, thus rendering it invalid – since it isn't the latest version inside the blockchain.

Another example is would be to check the status of your requests issued to the government (such as requests for granting citizenship). Querying the blockchain connected to e-government allows the request issuer to see how and where the request has been progressed.

When abstracted, requests are nothing more than regular documents which need to be approved or rejected due to some reason (e.g. missing additional documentation) by different entities. Each approval or rejection would be a patch to the original request, which can be read by the person which issued the original request.

In both examples the patches performed by the e-government cannot be changed in the future, without amending them across the whole blockchain. This means that the business process to handle document validity and to handle government requests cannot be modified by external modifications (e.g. by bribery) due to the distributed nature of the blockchain where a consensus on change needs to be reached (according to some consensus algorithm). In case of external modification, the system can be easily audited to determine where the anomaly has appeared.

5.2. Company accountability

The previous use case assumed that the blockchain is being hosted inside one entity (the government). It is also possible to host the blockchain both across companies and other entities, such as regulatory

committees. This would allow direct transparency into the subject matter without tampering. The condition to prevent tampering is selecting a consensus algorithm or having the critical number of blockchain nodes inside the company.

When the critical number of nodes belongs to the company (or the consensus algorithm is set in their favor), entities controlling the remainder cannot perform a takeover of the blockchain by issuing false data or denying incoming blockchain requests.

This node distribution can be useful for tracking government regulated goods (such as tobacco products or alcohol) between suppliers. Since the government has read-only access to the incoming blockchain requests, this removes the requirement of companies to produce reports concerning the sales and distribution of government regulated goods. An additional benefit is that the company's financial reports become easier to generate for the company. Furthermore, the government, since it has direct input into the current state of government regulated goods, can create more accurate tax rates and other regulation costs.

6. CONCLUSION

In this paper, we have proposed a framework which can be used for the development and research of document verification systems based on the blockchain. This system, by design, lowers the risk of document tampering and allows fast document verification. Documents are stored in document repositories, while their unique hashes are kept inside the blockchain. In order to add a document to the blockchain, a special request needs to be performed. Document modifications are performed by adding patches to the document repository and keeping track of their hash values inside the blockchain. When patches are added, the documents which are being amended need to be referenced. Verification is done by issuing a request containing the hash value of the document and receiving a positive or a negative response. Each request forms an entry inside a block. Each block delimits a specific time period. To perform any work on the blockchain, a consensus between nodes participating in the blockchain must be established.

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IMPROVING ROBERT C. MARTIN'S STABILITY SOFTWARE METRIC

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Abstract: *This paper discusses the problems of applying Robert C. Martin's Stability software metric when the influence of efferent or afferent couplings (C_e or C_a) on stability of a package is relativized. The problem of relativisation occurs in the cases when a package has (C_a=0 and C_e>0) or (C_a>0 and C_e=0). This problem has been defined by means of an overdetermined system of four equations containing two unknown variables and solved by applying the least squares method. The obtained solution allowed introduction of new stability software metric, we named BU Stability software metric. The new software stability metric improves Robert C.Martin's Stability software metric since it solves the problem of relativization of C_e and C_a. Finally, evaluation of BU Stability software metric is carried out to demonstrate that it cancels out the effect of relativization of C_e and C_a.*

Keywords*: Software quality, Software System, Afferent coupling, Efferent coupling, Software stability, Robert C. Martin's Stability software metric, BU Stability software metric*

1. INTRODUCTION

According to ISO/IEC 25010 (2011), software quality is one of the most important factor in the development of sustainable and reliable software systems. Pressman (2005) defines software quality as "an effective software process applied in a manner that creates a useful product that provides measurable value for those who produce it and those who use it". The benefits of the software quality are reflected in increased productivity of software development and maintenance and decreased cost and time-to-market.

The software quality attributes, such as maintainability, stability, reusability, extensibility, etc., are strongly related to software package dependency. Milic et al. (2017) points that software quality standard define the software quality attributes in terms of software metrics. According to Martin (2011, 2006), some of the well-known software metrics related to software package dependency are: Afferent coupling, Efferent coupling, Instability, Distance from the Main Sequence, and Package Dependence Cycles.

In this paper our attention is paid to Robert C. Martin's Stability software metric. Prior to pointing at the problems associated with the indicated metric, a brief explanation of the concept of software stability is given. The software stability, according to ISO 9126 (2001), "characterizes the sensitivity to change of a given system, i.e. the negative impact that may be caused by system changes". Yau and Collofello (1980, 1985) said that software stability is resistance to propagation of changes (ripple effect) that the software would have when it is modified. Meyer (1997) identifies this as modular continuity. Fayad and Altman (2001) points at the importance of identifying the areas in the project that are stable during the development of a software project. The Tang & Xuan (2012) paper that analyses dependency between component based software packages was very helpful for our understanding of software package dependency and its influence on software package stability. In the previous studies presented in Vlajic (2007, 2011), we have tried to define a formal basis for making stable and sustainable software systems, through explanation of the design patterns by the symmetry concepts and software entropy in the context of software maintenance.

This paper makes a critical analysis of Robert C. Martin's Stability software metric that quantitatively expresses the stability of a software package via Efferent and Afferent couplings (C_e and C_a). This metric exhibits deficiencies in two cases: a) the package has efferent but does not have afferent couplings (C_a=0 and C_e >0) and b) the package has afferent but does not have efferent couplings (C_a>0 and C_e=0). In the first case the influence of C_e on stability of the package is relativized, while in the second case the influence of C_a on stability of the package is relativized.

On the basis of these deficiencies, the problem has been defined by means of an overdetermined system of four equations having two unknown variables. It is well known that such systems, in general, do not have solutions. Therefore, there was a need to define 'solution' of such system. In that sense we have employed the least squares method, as presented in Nocedal and Wright (2006). The obtained solution made it possible for us to define a new software metric, called BU Stability software metric since it has been created at Belgrade University (BU), Faculty of Organizational Sciences, Department of Software Engineering.

The evaluation of the BU Stability software metric carried out at the end of the paper shows that this metric cancels out the effect of C_e and C_a relativization. BU Stability software metric will not impair Robert C. Martin's Stability software metric in the case when $C_e>0$ and $C_a>0$, in other words when there isn't problem of C_a and C_e relativization. Furthermore it is demonstrated in the cases when ($C_a=1$ and $C_e>0$) and ($C_a>0$ and $C_e=1$).

2. ROBERT C. MARTIN'S STABILITY SOFTWARE METRIC

The object-oriented Stability software metric, as described by Robert C. Martin (2011, 2006), is one of the most frequently used metrics for determination of package stability (component stability). By means of stability metric we obtain a quantitative measure of package stability which is significant for the maintenance, re-use and upgrade of the package. According to Robert C. Martin (2011, 2006), this metric has the following form:

$$I = \frac{Ce}{Ca + Ce'}, \tag{1}$$

where I is mark for Instability.

Stability software metric is based on Afferent couplings (Ca) and Efferent couplings (Ce) among the classes of the considered package (whose stability is being measured) and classes that are outside of this package. More precisely speaking, Ca refers to the number of classes outside the considered package that depend on classes within this package. Ce refers to the number of classes inside this package that depend on classes outside this package. Stability metric has the range [0,1]. If I = 0, the package has maximum stability. If I = 1, the package has maximum instability.

3. PROBLEM

Let us assume that we have packages Px, Py, and Pz containing classes X_1, Y, and Z_1 respectively. Class X_1 depends on the class Y, while class Y depends on the class Z_1. The dependencies between classes determine dependencies between the packages. Thus Px depends on Py, while Py depends on Pz (Fig. 1). Instability of package Py is I=1/2=0.5, since Ce = 1 and Ca =1.

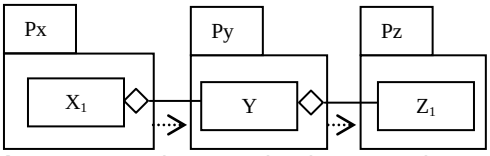

Figure 1: Package Py having Ce=1 i Ca=1

If a class Z_2 is added to package Pz, whereby class Y depends on class Z_2 (Fig. 2), then instability of package Py increases: I = 2/3=0.66, since Ce=2 and Ca=1.

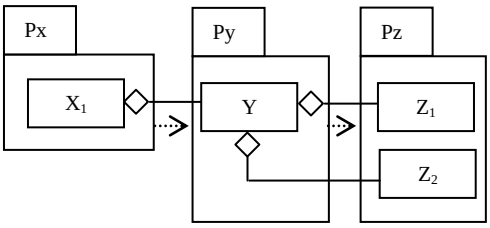

Figure 2: Package Py having Ce=2 and Ca=1

An increase of the number of classes (n) in package Pz would increase the instability of Py package. In an extreme case when n→∞, then I→1:

$$I = \lim_{n\to\infty} \frac{n}{1+n} = 1. \tag{2}$$

If in Fig. 1 class X_2 is added to package Px, whereby class X_2 depends on class Y, then instability of package Py decreases: I = 1/3 = 0.33, since Ce = 1 and Ca =2.
An increase of the number of classes (m) in package Px would decrease the instability of Py package. In an extreme case when m→∞, then I→0:

$$I = \lim_{m\to\infty} \frac{1}{m+1} = 0. \quad (3)$$

Stability of package Py, when (*Ca*=1 and *Ce*>0) and (*Ca*>0 and *Ce*=1), is presented in Table 1:

Table 1: Stability of package Py when (Ca=1 and Ce>0) and (Ca>0 and Ce=1)

Ca	***Ce***	***I= Ce/(Ca+Ce)***
1	*n*	→ 1
1	*n*-1	...
1	...	...
1	5	0.83
1	4	0.80
1	3	0.75
1	2	0.67
1	1	0.50
2	1	0.33
3	1	0.25
4	1	0.20
5	1	0.17
...	1	...
m-1	1	...
m	1	→ 0

We can conclude that increasing of Ce leads to increasing instability of package Py, while increasing of Ca leads to decreasing instability of package.

Deficiency of stability metric I is exhibited in two cases, addressed in Subsections 3.1 and 3.2.

3.1. Problem 1 – Relativization of Ce

In the first case, if the dependence between classes X_1 and Y disappears (*Ca*=0), see Fig. 1, instability of package Py becomes 1 (Fig. 3), since ***I***=1/(0+1).

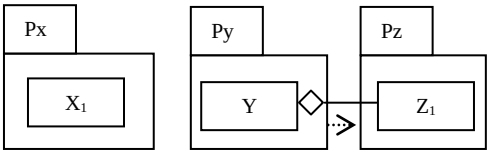

Figure 3: Package Py having *Ce*=1 and *Ca*=0

If class Z_2 is added to package Pz, instability of package Py remains 1 (***I***=2/(0+2)). We can conclude that the increasing Ce does not change instability of package Py which is always 1, since I=Ce/(0+Ce) for Ca=0.

We consider that deficiency of stability metric I is caused by Ce relativisation when Ca=0 and therefore should be removed from the metric.

The relativization of *Ce*, when *Ca*=0 is presented in Table 2:

Table 2: Relativization of Ce when Ca=0

Ca	***Ce***	***I= Ce/(Ca+Ce)***
0	1	1
0	2	1
0	3	1
0	4	1
0	5	1
0	...	1
0	*n*-1	1
0	*n*	1

3.2. Problem 2 – Relativization of Ca

In the second case, if the dependence between classes Y and Z_1 disappears (*Ce*=0), see Fig. 1, instability of package Py becomes 0 (Fig. 4), since ***I***=0/(1+0).

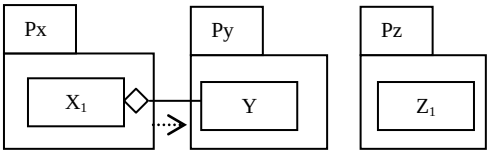

Figure 4: Package Py having *Ce*=0 and *Ca*=1

If class X_2 is added to package Px, instability of package Py remains 0 (***I***=0/(2+0)). We can conclude that the increasing Ca does not change instability of package Py which is always 0, since I=0/(Ca+0) for Ce=0.

We consider that deficiency of stability metric I is caused by Ca relativisation when Ce=0 and therefore should be removed from the metric.

The relativization of Ca, when Ce=0 is presented in Table 3:

Table 3: Relativization of Ca when Ce=0

Ca	***Ce***	***I= Ce/(Ca+Ce)***
1	0	0
2	0	0
3	0	0
4	0	0
5	0	0
...	0	0
m-1	0	0
m	0	0

We can summarize problems 1 and 2, i.e. the problems of relativization *Ce* and *Ca*, in Table 4:

Table 4: Stability of package Py when (*Ca*=0 and *Ce*>0) and (*Ca*>0 and *Ce*=0)

Ca	***Ce***	***I= Ce/(Ca+Ce)***
0	*n*	1
0	*n*-1	1
0	...	1
0	5	1
0	4	1
0	3	1
0	2	1
0	1	1
1	0	0
2	0	0
3	0	0
4	0	0
5	0	0
...	0	0
m-1	0	0
m	0	0

The problem of relativization Ce (when Ca=0) and Ca (when Ce=0) will be solved if we determine stability metric ***Ir*(δ_1, δ_2)**, i.e. variables δ_1 and δ_2 of *Ir*, so that stability metric ***Ir* (δ_1 , δ_2)** satisfies a condition (**US_1**): **1> ...> a> b> c> d> ...> 0**. This problem is presented in Table 5.

Stability metric ***I*r** is denoted by letter ***I*** implying instability, and also by letter **r** implying relativization of *Ce* and *Ca*.

Table 5: The problem of relativization of *Ce* and *Ca* when (*Ca*=0 and *Ce*>0) and (*Ca*>0 and *Ce*=0)

Ca	***Ce***	***Ir*(δ_1, δ_2) = (*Ce*+ δ_1)/(*Ca* + *Ce*+δ_2)**
0	*n*	$\rightarrow 1$
0	...	...
0	2	$Ir_1(\delta_1, \delta_2) = a$
0	1	$Ir_2(\delta_1, \delta_2) = b$
1	0	$Ir_3(\delta_1, \delta_2) = c$
2	0	$Ir_4(\delta_1, \delta_2) = d$
...	0	...
m	0	$\rightarrow 0$

4. SOLUTION

The stability metric ***Ir*** can be represented by a system:

$$\begin{gathered} \mathbf{I_{r1}(\delta 1, \delta 2) = a,} \\ \mathbf{I_{r2}(\delta 1, \delta 2) = b,} \\ \mathbf{I_{r3}(\delta 1, \delta 2) = c,} \\ \mathbf{I_{r4}(\delta 1, \delta 2) = d,} \end{gathered} \tag{4}$$

where 1>a>b>c>d>0.

Taking into account values of Ce and Ca from Table 5, we obtain a system of four equations containing two unknowns:

$$\begin{gathered} (2+ \delta_1)/(2+ \delta_2) = a, \\ (1+ \delta_1)/(1+ \delta_2) = b, \\ \delta_1/(1+ \delta_2) = c, \\ \delta_1/(2+ \delta_2) = d, \end{gathered} \tag{5}$$

which can be written in the form:

$$\begin{gathered} \delta_1 - a\delta_2 - 2a + 2 = 0, \\ \delta_1 - b\delta_2 - b + 1 = 0, \\ \delta_1 - c\delta_2 - c = 0, \\ \delta_1 - d\delta_2 - 2d = 0. \end{gathered} \tag{6}$$

The overdetermined systems, like (6), in general have no solutions. Nevertheless, we introduce the concept of 'solution' of system (6) following the idea of the least squares method. As a solution of system (6) we will imply ordered pair ($\boldsymbol{\delta_1}$, $\boldsymbol{\delta_2}$) giving minimum function of square deviation.

$$\mathbf{F(\delta_1, \delta_2) = (\delta_1 - a\delta_2 - 2a + 2)^2 + (\delta_1 - b\delta_2 - b + 1)^2 + (\delta_1 - c\delta_2 - c)^2 + (\delta_1 - d\delta_2 - 2d)^2} \tag{7}$$

Such solution is obtained by solving the system of equations:

$$\begin{gathered} \frac{\partial F}{\partial \delta_1} = 0, \\ \frac{\partial F}{\partial \delta_2} = 0. \end{gathered} \tag{8}$$

In the present case, the system has form:

$$\begin{gathered} 2(\delta 1 - a\delta 2 - 2a + 2) + 2(\delta 1 - b\delta 2 - b + 1) + 2(\delta 1 - c\delta 2 - c) + 2(\delta 1 - d\delta 2 - 2d) = 0, \\ -2a(\delta 1 - a\delta 2 - 2a + 2) - 2b(\delta 1 - b\delta 2 - b + 1) - 2c(\delta 1 - c\delta 2 - c) - 2d(\delta 1 - d\delta 2 - 2d) = 0. \end{gathered} \tag{9}$$

This system can be simplified to a system:

$$\begin{gathered} 4\delta_1 - (a+b+c+d)\delta_2 = 2a+b+c+2d-3, \\ (a+b+c+d)\delta_1 - (a^2+b^2+c^2+d^2)\delta_2 = 2a^2+b^2+c^2+2d^2-2a-b, \end{gathered} \tag{10}$$

which is linear with respect to δ_1 and δ_2. The previously described system (10) will be illustrated by the case when, e.g. a = 0.6, b=0.55, c=0.45 and d=0.4. In this case system (10) is reduced to:

$$\begin{gathered} 2\delta_1 - \delta_2 = 0 \\ -2\delta_1 - 1.025\delta_2 = 0.205, \end{gathered} \tag{11}$$

whose solution is: $\boldsymbol{\delta_1 = 4.1}$, $\boldsymbol{\delta_2 = 8.2}$.
This solution represents solution of stability metric **Ir (4.1,8.2)**, which can be presented as:

$$Ir = \frac{Ce + 4.1}{Ca + Ce + 8.2}, or$$

$$Ir = \frac{Ce + \delta_1}{Ca + Ce + 2\delta_1}, for\ \delta_1 = 4.1. \tag{12}$$

If we introduce substitution:

$$Ce' = Ce+\delta_1, \quad Ca' = Ca+\delta_1, \tag{13}$$

Ir can be represented in the following form:

$$Ir = \frac{Ce'}{Ca'+Ce'}, \text{ with } Ce' = Ce+\delta_1,\ Ca' = Ca+\delta_1,\ \delta_1 = 4.1. \tag{14}$$

Software metric *Ir* improves the Stability software metric of Robert C. Martin, since it solves the problem of relativization of *Ce* (when *Ca*=0) and *Ca* (when *Ce*=0).

Remark: As we have seen, determination of variables δ_1 and δ_2 was dependent upon solvability of system (10). Now, we shall show that this system always has a solution for any set of values *a*,*b*,*c,* and *d* satisfying condition 1>*a*>*b*>*c*>*d*>0. Indeed, since determinant of the system is:
$D = (a+b+c+d)^2-4(a^2+b^2+c^2+d^2) = -[(a-b)^2+(a-c)^2+(a-d)^2+(b-c)^2+(b-d)^2+(c-d)^2]$,
obviously D≠0 for 1>a>b>c>d>0, thus system (10) has a unique solution in relation to $\boldsymbol{\delta_1}$ and $\boldsymbol{\delta_2}$.

5. EVALUATION

If software metric Ir is applied for obtained solution of the first problem (Fig. 5), where Ce is relativized, in the case when Y is related to Z_1 and the relation between X and Y does not exist, instability of package Py will be: Ir=5.1/9.2 ≈ 0.55.

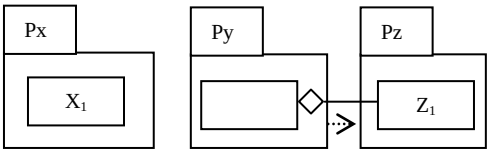

Figure 5: Package Py having *Ce*=1 and *Ca*=0

In the case when class Z_2 is added to package Pz, instability of package Py will be Ir=6.1/10.2 ≈ 0.6. With increasing of Ce, instability of package Py will keep increasing, converging towards 1. We consider that software metric Ir improves software metric I and cancels out the effect of Ce relativization, when Ca=0, since instability of package Py is increasing with increasing of Ce (Table 6).

Table 6: Cancelation of the effect of Ce relativization when Ca=0

Ca	Ce	Ca'	Ce'	Ir= Ce'/(Ca'+Ce')
0	*n*	4.1	*n*+4.1	→ 1
0	*n*-1	4.1	*n*+3.1	...
0	...	4.1	...	...
0	5	4.1	9.1	0.69
0	4	4.1	8.1	0.66
0	3	4.1	7.1	0.63
0	2	4.1	6.1	0.60
0	1	4.1	5.1	0.55

If software metric ***Ir*** is applied for obtaining solution of the second problem (Fig. 6), where *Ca* is relativized, in the case when X_1 is related to Y and relation between Y and Z_1 does not exist, instability of package Py will be: ***Ir*=**4.1/9.2 ≈ 0.44.

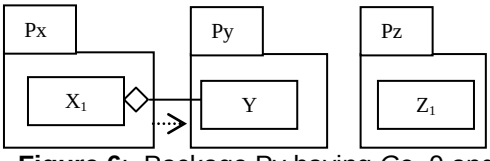

Figure 6: Package Py having *Ce*=0 and *Ca*=1

In the case when class X_2 is added to package Px, instability of package Py will be: ***Ir*=**4.1/10.2 ≈ 0.4. With increasing of Ca, instability of package Py will keep decreasing, converging towards 0. We consider that

software metric Ir improves software metric I and cancels out the effect of Ca relativization, when Ce=0, since instability of package Py is decreasing with increasing of Ca (Table 7).

Table 7: Cancelation of the effect of Ca relativization when Ce=0

Ca	Ce	Ca'	Ce'	Ir= Ce'/(Ca'+Ce')
1	0	5.1	4.1	0.45
2	0	6.1	4.1	0.40
3	0	7.1	4.1	0.37
4	0	8.1	4.1	0.34
5	0	9.1	4.1	0.31
...	0	...	4.1	...
m-1	0	*m*+3.1	4.1	...
m	0	*m*+4.1	4.1	→ 0

Software metric I_r represents a solution of the problem of Ca and Ce relativization and it can be presented as: $I_r = Ce'/(Ca'+Ce')$, with $Ce' = Ce+\delta_1$, $Ca' = Ca+\delta_1$, for $\delta_1 =$ 4.1 (Table 8).

Table 8: Solution of the problem of *Ce* and *Ca* relativization when (*Ca*=0 and *Ce*>0) and (*Ca*>0 and *Ce*=0)

Ca	Ce	Ca'	Ce'	I	Ir
0	*n*	4.1	*n*+4.1	1	→ 1
0	*n*-1	4.1	*n*+3.1	1	...
0	...	4.1	...	1	...
0	5	4.1	9.1	1	0.69
0	4	4.1	8.1	1	0.66
0	3	4.1	7.1	1	0.63
0	2	4.1	6.1	1	0.60
0	1	4.1	5.1	1	0.55
1	0	5.1	4.1	0	0.45
2	0	6.1	4.1	0	0.40
3	0	7.1	4.1	0	0.37
4	0	8.1	4.1	0	0.34
5	0	9.1	4.1	0	0.31
...	0	...	4.1	0	...
m-1	0	*m*+3.1	4.1	0	...
m	0	*m*+4.1	4.1	0	→ 0

It should be stressed that software metric I_r will not disturb the existing software metric *I* in cases when *Ce*>0 and *Ca*>0, i.e. when the problem of relativization of *Ce* and *Ca* does not appear. In addition, e.g. when (*Ca*=1 and *Ce*>0) and (*Ca*>0 and *Ce*=1), the corresponding values of metrics *I* and I_r are decreasing (Table 9) from 1 towards 0.The ratio between the corresponding values in both metrics is maintained. This means that ratio *I*(*i*)/*I*(*i*+1), *i*=1, 2, ..., *r*, remains the same as the ratio *Ir*(*i*)/*Ir*(*i*+1). For example, if *i*=*p*+2, then *I*(*p*+2)>*I*(*p*+3), 0.80>0.75; the same ratio remains for *I*r, i.e. *I*r(*p*+2)>*I*r(*p*+3) or 0.61>0.58.

Table 9: Stability of package Py when (*Ca*=1 and *Ce*>0) and (*Ca*>0 and *Ce*=1)

Row	Ca	Ce	Ca'	Ce'	I	I_r
1	1	*n*	5.1	*n*+4.1	→ 1	→ 1
2	1	*n*-1	5.1	*n*+3.1	...	...
...	1	...	5.1	...	...	...
p	1	...	5.1	...	...	...
p+1	1	5	5.1	9.1	0.83	0.64
p+2	1	4	5.1	8.1	0.80	0.61
p+3	1	3	5.1	7.1	0.75	0.58
p+4	1	2	5.1	6.1	0.67	0.54
p+5	1	1	5.1	5.1	0.50	0.50
p+6	2	1	6.1	5.1	0.33	0.46
p+7	3	1	7.1	5.1	0.25	0.42
p+8	4	1	8.1	5.1	0.20	0.39
p+9	5	1	9.1	5.1	0.17	0.36
...	...	1	...	5.1	...	...
r-1	*m*-1	1	*m*+3.1	5.1	...	...
r	*m*	1	*m*+4.1	5.1	→ 0	→ 0

6. CONCLUSION

We have improved Robert C. Martin's Stability software metric in the cases when the influence of the efferent and afferent couplings upon stability of a considered package is relativized. At first, Robert C. Martin's Stability software metric has been explained: $I = \frac{Ce}{Ca+Ce}$.

Then, the deficiency of this metric has been identified and illustrated. This deficiency occurs when a considered package has either no afferent or no efferent coupling (Ca=0 or Ce=0). If I stability metric has no afferent coupling (Ca=0) and has efferent coupling (Ce>0), then the efferent couplings is relativized. If I stability metric has no efferent coupling (Ce=0) and has afferent coupling (Ca>0), then the afferent copuplings is relativized.

The indicated problem has been represented by means of an overdetermined system of four equations containing two unknown variables and solved by applying the least squares method. The solution has been presented in terms of software metric I_r: $Ir = \frac{Ce'}{Ca'+Ce'}$, with $Ce' = Ce+\delta_1$, $Ca' = Ca+\delta_1$, $\delta_1 = 4.1$.

Software metric I_r improves software metric I because Ir solves the problem of relativization of Ce (when Ca=0) and Ca (when Ce=0), which was identified as a deficiency of software metric I. It was stressed that software metric I_r will not disturb software metric I in the cases when Ce>0 and Ca>0, i.e. when the problem of Ce and Ca relativization does not occur. This was demonstrated in the cases when (Ca=1 and Ce>0) and (Ca>0 and Ce=1). Since the obtained software metric has been created at **B**elgrade **U**niversity (**BU**) we named it "**BU Stablity software metric**".

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ANALYSIS OF DYNAMIC CONTENT RENDERING IN JAVASCRIPT TECHNOLOGIES

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Abstract: *In this paper we have described how a html content can be dynamically replaced using different libraries and frameworks. Practical example of dynamic content rendering was realized through jQuery, JsRender and Angular. Differences and similarities as well as advantages and disadvantages will be presented in the analysis where different aspects, such as load time, ease of maintenance, adjusting to changes must be taken into consideration. Analysis of selected libraries and frameworks was conducted in order to make a decision whether to use or not to use a framework.*

Keywords*: Dynamic content, JavaScript, jQuery, JsRender, Angular*

1. INTRODUCTION

JavaScript programming language is almost an inevitable part of nowadays web applications. Providing dynamic and interactive experience for the user has become an imperative. The number of JavaScript frameworks which help us achieve this, has increased considerably in the last few years. Choosing the appropriate framework has become a challenge. (Crockford, 2008)

Flexible and interactive applications that quickly respond to user requests have a lot of dynamic content. Rendering such content may take some time. In order to improve a web page's interactivity and usability the shortening of rendering time can be achieved by simply updating part of the page instead of the entire web page. There are various ways to do this and they will be presented in this paper. Analysis of these technologies is based on various factors such as load time, ease of maintenance, adjusting to changes. (Ambler & Cloud, 2015)

A brief overview of client and server-side rendering and importance of JavaScript in Web applications development is given in the second chapter. An example of dynamic content rendering is realized by using jQuery, JsRender and Angular. The solution of the same problem, in different ways, is shown by using each of them. Specifics for each technology are shown through snippets of code.

Many authors conducted a comparative analysis of JavaScript frameworks. A detailed study was conducted by Pano, Graziotin and Abrahamsson (v6. 2018) in order to identify and understand the factors that influence the choice of a JavaScript framework. According to them, actors leading to the adoption of a JavaScript Framework are customer, developer, team and team leader. Factors leading to the adoption are performance expectancy, effort expectancy, social influence, facilitating conditions and price value. (Pano, Graziotin, & Abrahamsson, 2018)

Analysis conducted in the fourth chapter is aimed at making a decision whether to use or not to use a framework considering dynamic content rendering. Conclusions and our vision of future work are described in the fifth chapter.

2. DYNAMIC CONTENT RENDERING

Unlike traditional web applications that mostly relied on server-side rendering, modern web applications generally involve client-side rendering. Server-side rendering implies that browser make a request to the server and gets rendered HTML. It is often necessary to render only a certain component on a page as opposed to loading of the entire page from server. This feature is one of the basic characteristics of Single-page applications. Impression of a “native” environment in the browser (like a desktop application), without page reloads in order to quickly respond to user actions. Remarkable user experience is just one of the advantages of this approach. Client-side rendering implies using JavaScript to render content in the browser. (Brikman, 2015)

“JavaScript is a programming language used primarily by Web browsers to create a dynamic and interactive experience for the user.” (Flanagan, 2011) ECMAScript is the official name for JavaScript. In a common context JavaScript applies to a programming language, while ECMAScript applies to language specification. The current version of JavaScript is ECMAScript 8, from June 2017. (Rauschmayer, 2014) Unlike earlier, static, nowadays web pages mean more interactions, features like floating menus, add sound, display advertisements, animations, etc. Those features can be realized by different tools, and JavaScript is one of the most prominent ones. (Kiong, 2018)

Simple, multi-paradigm (scripting, object-oriented, imperative, functional) programming language, easy for learning – JavaScript has become an inevitable part of nowadays web applications. There are many JavaScript plugins, libraries and frameworks, and some of them are the subject of this paper.

2.1. jQuery

JQuery is defined as “fast, small, and feature-rich JavaScript library”. (jQuery, 2018) Initial release of jQuery was on 2006, and since then until today stands for the most popular JavaScript library. (Miles, 2016)

The major components of jQuery:

- The DOM selection – methods which help finding elements in document object model
- DOM manipulation – manipulation methods that modify previously found elements
- Events – handling events as a precondition for creation a dynamic website
- Form – methods for easier sending information back to a server
- CSS and animation – methods for handling classes, locations and dimensions of elements
- Ajax - methods for exchanging data with a serve
- Helpers – to iterate over a collection, determine the type of object and many others (Miles, 2016)

One of the main ideas was to save coding time (no more writing plumbing code) and focuses on essential functionalities which can be seen in the JQuery’s motto “write less, do more”. (Miles, 2016)

2.2. JsRender

Described as “A lightweight, powerful and highly extensible templating engine”, JsRender supersede jQuery Templates plugin. (JsRender, 2018) Optimized for high-performance rendering, without DOM dependency, JsRender is used for data-driven rendering of templates to strings. (JsRender, 2018)

JsViews platform adds data binding to JsRender templates and together provide fully-fledged MVVM platform for creation interactive single page applications and websites. JsRender can be used with or without jQuery. (JsRender, 2018)

Template can be defined from a string,

```
var template = $.templates("City: {{:city}}");
```

or in a script block as markup. (JsRender, 2018)

```
<script id="myTemplate" type="text/x-jsrender">
City: {{:city}}
</script>
```

With render function we can render a template as below.

```
var city = {city: "Belgrade"};
var html = template.render(city);
```

An array also can be passed, then template renders for each element in the array. (JsRender, 2018)

There are many tags in JsRender which enable iterate over arrays, over object’s properties, conditional inclusion and other useful features.

2.3. Angular

Client-side web application as one of the models for modern applications tend to be more flexible and interactive with quickly responds to user requests. (Clow, 2018) One of the most popular frameworks for this

purpose is Angular. Defined as “a platform and framework for building client applications in HTML and TypeScript” (Architecture overview, 2018) Angular is one of the most popular JavaScript frameworks.

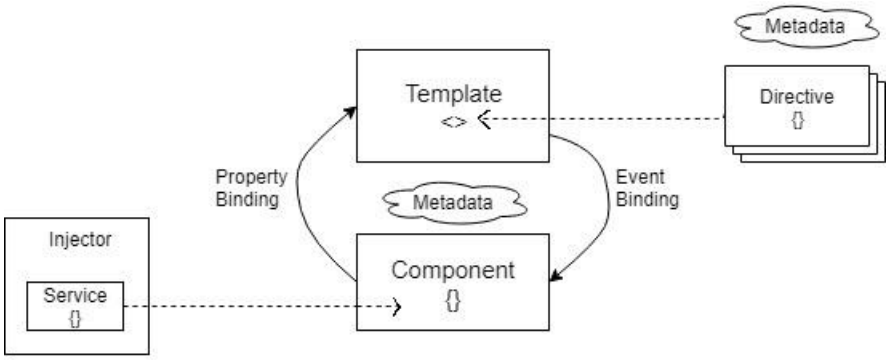

Figure 1: Architecture overview

Main building blocks of an Angular application and their relations are shown in Figure 1. NgModules as a fundamental building block provides a compilation context for components. Application is defined by a set of NgModules. Components define views and use services which provide specific functionality. In order to take advantage of lazy-loading NgModules loading on demand. Data and logic are located in classes defined by component associated with a HTML template. To modify HTML elements a template combines HTML with Angular markup. Two-way data binding is supported. For some data or logic which needs to be shared across components and not connected with a specific view, it is possible to create service class. Metadata are provided by @Injectable decorator that allows services to be injected into components as a dependency. (Architecture overview, 2018)

3. AN EXAMPLE OF DYNAMIC CONTENT RENDERING IN SELECTED TECHNOLOGIES

The HTML page has many interconnected components. Some of them change more often than others. In order to improve a web page's interactivity and usability it is possible to avoid rendering of the entire page, but only to render a certain component on a page. User interactions on one component can cause rendering of another component on the page. The related components affect one another, and their synchronization can be realized in several ways. Hiding, changing content are just some of the most common user interactions that will be presented.

Problem setting

It is necessary to create drop-down list whose elements are continents. After choosing a particular continent, a table with countries belonging to the selected continent should be displayed. Continent is determined by name and collection of countries, while a country is determined by name, capital and population.

At the beginning, the look of the component is shown in Figure 2.

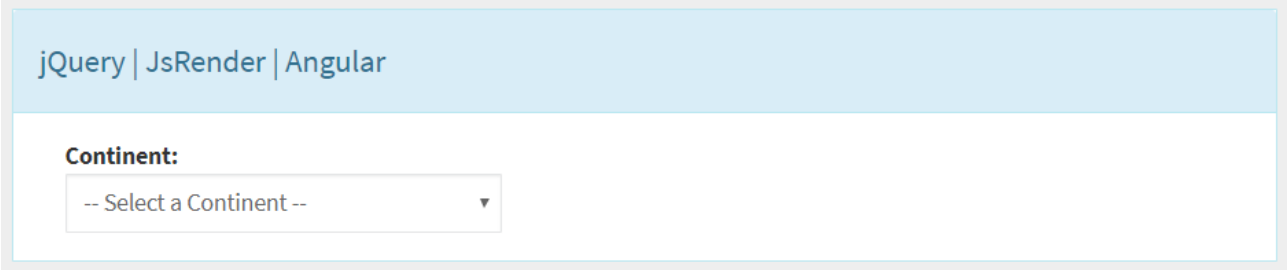

Figure 2: The look of a component

After choosing a particular continent, a table with countries is displayed as is shown in Figure 3.

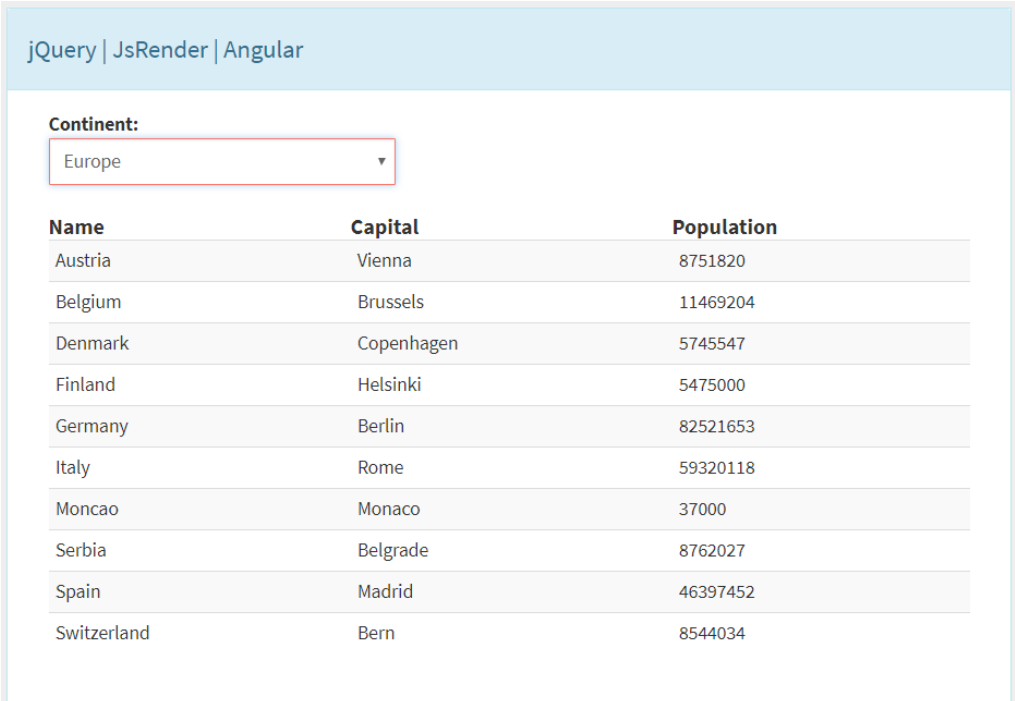

Figure 3: Displayed table with countries

Solution of the problem

3.1. jQuery

Bootstrap is used to stylish a HTML page.

```
<div class="panel-body">
    <div id="continent-container" class="container">
        <div class="row col-md-3">
            <label>Continent:</label>
            <select id="continent" class="form-control">
                <option id="-1" disabled selected>-- Select a Continent --</option>
            </select>
        </div>
    </div>

    <div id="countries-container" class="container col-md-12"> </div>
</div>
```

Drop-down list is created by select element. Initially there is only one option. The received data, continents, should be added as options. One of the ways is presented in code snippet below.

```
$.each(continents.continents, function (index, continent) {

    $("#continent").append($("<option>", { id: continent.continentId})
                   .text(continent.continentName));
});
```

The append() method was used. This method “insert content, specified by the parameter, to the end of each element in the set of matched elements”. (append, 2018) Prepend() method is similar, the difference is that content is inserted as a fist child.

After adding continents to drop-down list, it is necessary to define what happens by selecting a particular continent or in jQuery’s language define what happens on click on the continent element.

```
        var selectedContinentId = $(this).find('option:selected').attr('id');

        var selectedContinent = $.grep(continents.continents, function (continent) {
            return continent.continentId == selectedContinentId;
        })[0];
```

To find a selected continent, in order to find belonging countries, the method grep was used. This method "finds the elements of an array which satisfy a filter function". (jquery.grep, 2018)

```
 if (selectedContinent != undefined && selectedContinent.countries.length > 0) {

    var $table = $('<table id="countries-table" class="table table-striped"></table>');
    var $tHead = $('<tr> <th> Name </th> <th> Capital </th> <th> Population </th> </tr>');
    var $tBody = $('<tbody></tbody>');

    $.each(selectedContinent.countries, function (index, country) {
        var $tr = $('<tr> <td>' + country.countryName + '</td> <td>' + country.capital +
                    '</td> <td>' + country.population + '</td>');
        $tBody.append($tr);
    });

    $table.prepend($('<br/>'));
    $table.append($tHead).append($tBody);
    $("#countries-container").append($table);
}
```

As shown in code snippet above, after defining table, table head and table body, for each country of a selected continent a new row is being created and added in table body. In the end, created table is added to countries-container.

3.2. JsRender

Panel body is almost identical as in the previous example, except that a select element initially has no options. The received data, continents, should be added as options. At the beginning the template was created.

```
    <script id="continent-template" type="text/x-jsrender">

        <option id="-1" selected>-- Select a Continent --</option>
        {{for continents}}
        <option id="{{>#data.continentId}}">{{>#data.continentName}}</option>
        {{/for}}

    </script>
```

After passing an array to JsRender, the template will be the same for every element in the array. Inner content in script will not be parsed as JavaScript by adding the text/x-jsrender attribute on the script. (Matthews & Gliser, 2015) To get the compiled template it was used $.templates() method with a jQuery selector. Next step is for render to obtain template according to the given data (continents), and get the HTML output as a string. In the end we inserted that output into the continent element. (JsRender, 2018) The previously described procedure is shown in code snippet below.

```
     var template = $.templates("#continent-template");
     var htmlOutput = template.render(continents);
     $("#continent").empty();
     $("#continent").html(htmlOutput);
```

As in the previous example, after adding continents to drop-down list, it is necessary to define what happens by selecting a particular continent. Finding a selected continent is identical as in the previous example. It is necessary to create a new template for countries.

```
<script id="country-template" type="text/x-jsrender">
    {{if countries.length > 0}}
    <br />
    <table class="table table-striped">
        <thead>
                ...
        </thead>
        <tbody>
            {{for countries}}
            <tr>
                <td>{{>#data.countryName}}</td>
                <td>{{>#data.capital}}</td>
                <td>{{>#data.population}}</td>
            </tr>
            {{/for}}
        </tbody>
        {{/if}}
    </table>
</script>
```

Countries of selected continent are given to template for rendering and output has been inserted into the countries container as shown below.

```
$("#countries-container").empty();

if (selectedContinent[0] != undefined) {
    var template = $.templates("#country-template");
    var htmlOutput = template.render(selectedContinent[0]);
    $("#countries-container").empty();
    $("#countries-container").html(htmlOutput);
}
```

3.3. Angular

Defining classes is the first step.

Continent class

```
export class Continent {
  constructor(public continentId: number, public continentName: string, public
          countries: Country[]) {
  }
}
```

Country class

```
export class Country {
  constructor(public countryId: number, public countryName: string, public capital:
              string, public population: number) {
  }
}
```

Panel body is similar to the previous examples.

```
<div id="continent-container" class="container">
  <div class="row col-md-3">
    <label>Continent:</label>
    <select id="continent" [(ngModel)]="selectedContinent" class="form-control">
      <option [ngValue]="null" disabled>-- Select a Continent --</option>
      <option *ngFor="let continent of continents"
              [ngValue]="continent">{{ continent.continentName }}
      </option>
    </select>
  </div>
</div>
```

Using the ngFor directive it is possible to iterate over continents collection. Current element is defined as continent. Each element of collection becomes an option which value is continent as object and text is continent's name. An example of two-way binding is given in [(ngModel)] = "selectedContinent". HTML element select is associated with selectedContinent variable from TypeScript component and the change on either side is reflected on the other. A HTML component is associated with TypeScript component.

```
export class AppComponent {

  public continents: Continent[];
  public selectedContinent: Continent;

  constructor() {
    this.continents = ...
    this.selectedContinent = null;
  }
}
```

The previously described connection between elements and properties is now clearer.
As in the previous example, after adding continents to drop-down list, it is necessary to define what happens by selecting a particular continent. Finding a selected continent is much simpler than in previous examples. If conditions defined by ngIf are met, access to the countries of a selected continent implies iteration through an array. Unlike previous examples where we had to find selected continent object in continents collection, now we just need to take selectedContinent variable and we can access the associated attributes. Previously explained two-way binding will provide up-to-date information at any time.

```
<br *ngIf="selectedContinent && selectedContinent.countries.length > 0"/>
<div id="countries-container" class="container col-md-12" *ngIf="selectedContinent
         && selectedContinent.countries.length > 0">
  <table class="table table-striped">
    <thead> ... </thead>
    <tbody>
    <tr *ngFor="let country of selectedContinent.countries">
      <td>{{ country.countryName }}</td> <td>{{ country.capital }}</td>
      <td>{{ country.population }}</td>
    </tr>
    </tbody>
  </table>
</div>
```

4. ANALYSIS OF DYNAMIC CONTENT REPLACEMENT IN SELECTED TECHNOLOGIES

Each framework is oriented towards the concrete problem, but all of them serve the same purpose - to make dynamic and interactive experience for the user. Frameworks give liberty to developers to focus on functionalities without taking too much care about the structure. The most frequent comparisons are ones in which frameworks are compared between each other. In order to make a decision whether to use or not to use a framework, some relevant factors can be closer examined as given below.

4.1. Based on load time aspect

Measuring page's loading time in used example, JsRender showed the best results. Not far behind JsRender is jQuery which took a little longer time to load, and following jQuery is Angular which showed the slowest results in this scenario. The difference in performance on the side of the user would be more obvious with the more complex example. The application usually contains lots of feature modules which are loaded all at once. Often there is no need for this, so lazy loading can help reducing the size of bundle when the app loads initially implies reducing loading time which improves user experience. Computer hardware specification is constantly improving and has better performances as well as browsers' JavaScript engines, so the concern about the speed is becoming a minor problem.

4.2 Based on ease of maintenance aspect

Today's applications have hundreds of lines of code in whose realization participate independent teams. Maintaining these applications is getting harder and harder. Developers often forget that it is not only important to write code that solves the problem, but also the one that is efficient. Maintaining a code is about finding better ways to resolve a problem. The code is usually maintained by someone who has not written it which slows down the process. Duplicated coding, divergence from coding standards and bad code structure are often the cause of severe and long-lasting maintenance which has a significant impact on the budget. Maintenance is much easier and faster in an Angular than in jQuery or JsRender. Automatically generated code that synchronizes the Model and the View is one of the benefits of using Angular. Based on this example it can be concluded that jQuery generates more lines of code than the other two. One of other flaws of jQuery is that a HTML element was built by string concatenation and the browser will still have to parse it. Also, jQuery code is not readable and maintainable as code in templates used in the JsRender, and especially in the Angular. It is easier to maintain JsRender code, but as it is most often combined with jQuery functions, that is what makes it more difficult to maintain a complete application.

4.3 Based on adjusting to changes aspect

In order to stay competitive, applications should adapt to constant changes and new challenges. Customer requests are often changed and companies must be ready to meet them, otherwise they could lose a competitive advantage. Depending on how the code is structured, changes will be more difficult or easier to apply. Let's consider the problem of calculating the average population of countries.

In jQuery that would mean adding a new html element by string concatenation and additional calling of append() method. The average is calculated by iteration through all the countries of the selected continent as is shown below.

```
var averagePopulation = ((selectedContinent.countries.map(function (country) {
                          return country.population; }).reduce(
                          function (sum, population) { return sum + population; })) /
                           selectedContinent.countries.length).toFixed(2);

var $tFoot = $('<tfoot><tr><th></th> <th> Average population </th> <th>' +
                averagePopulation + '</th> </tr></tfoot>');


$table.append($tHead).append($tBody).append($tFoot);
```

In Agular it is necessary to add *tfoot* element in html

```
<tfoot>
 <tr>
   <th></th>
   <th>Average population</th>
   <th>{{ averagePopulation() }}</th>
 </tr>
</tfoot>
```

and calculate average population in TypeScript.

```
averagePopulation(): string {
  return (this.selectedContinent.countries.reduce((sum, country) => sum +
          country.population, 0) / this.selectedContinent.countries.length).toFixed(2);
}
```

In JsRender example this would imply changing the template.

```
<script id="country-template" type="text/x-jsrender">
    {{* window.total = 0}}
    {{* window.length = 0}}
    {{if countries.length > 0}}
                ...
        {{for countries}}
        {{* total += data.population}}
        {{* length += 1}}
                ...
        {{/for}}
      </tbody>
      <tfoot>
        {{* window.average = (total/length).toFixed(2)}}
        <tr>
          <th></th> <th>Average population</th> <th>{{*: average}} </th>
        </tr>
      </tfoot>
      {{/if}}
    </table>
</script>
```

Angular proved to be the easiest to adjust, then JsRender, then jQuery.

5. CONCLUSIONS AND FUTURE WORK

From the conducted analysis and practical example, several conclusions can be outlined. Answer the question whether to use or not to use a framework depends on array of different but interconnected factors, analyzed in this paper. On the basis of previously mentioned facts, the question might arise why we do not always use Angular when it has been proved to be the best solution for most problems. When developing a lightweight application without too much user interaction and dynamics, Angular would be a costly solution. If the separate, static, pages are the basics of the site and intended to be presented to search engines Angular would not be a good solution. When discussing the choice, the time and the human (in terms of developer's knowledge) limitations should be considered. Finding a pattern which could help about this decision looks like a tough task. The user usually does not describe his needs precisely and constantly has additional requirements, most of which cannot be foreseen. There are always some requirements or functionalities that could be done in a better way in other technology. That is why technologies are often combined which most often leads to acceptable solution. However, combining technologies is not universal solution and it could cause additional issues which should be examined in detailed.

In order to make the right decision, it is necessary to look at all the constraints, to precisely determine what should be achieved, taking into consideration the variability in the future. Finding the intersection between mentioned constraints and possibilities that technology delivers is crucial for fining the optimal solution for a given problem.

For the purpose of this research jQuery, JsRender and Angular were considered. Next step would be to include more components in analysis, categorize them according to different types of requests and repeat the previous analysis.

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DEVELOPMENT OF AN E-RECRUITMENT PORTAL USING MEAN STACK TECHNOLOGIES

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Abstract: *This paper presents the development of an e-recruitment portal using MEAN stack technologies. The goals of the portal are job and internship advertising, easy and efficient search and e-recruitment. The developed portal is an aggregator of business proposals and intermediary in the process of e-recruitment. Students and workers looking for employment have the ability to send curriculum vitae via electronic applications. Valid applications collected via the portal are being forwarded to potential employers. Use of the developed model enhances the process of connecting employers with those who seek employment. Finally, the paper points out the specifics and advantages of using MEAN stack technologies for developing e-recruitment portals.*

Keywords*: E-business, electronic employment offers, e-recruitment, portal for e-recruitment, aggregator*

1. INTRODUCTION

Employers often face the need to find competent candidates who can meet hiring needs with their knowledge and skills. Many companies, for the purpose of employing suitable candidates, use the Internet as a mean of entering the e-market of labor. Anyone looking for a job, over the Internet, on e-market of labor, can easily obtain information about employment offers in their field of interest. Web portals play an important role in facilitating and accelerating mediation in the employment process. For people seeking an employment, the existence of “job search” portals is of high importance (Stevenson, 2008). Portals of this kind are mostly aggregators of employment offers of different companies. For the ones seeking a job, they provide an overview of job and internship offers (Mitrović, 2010).

E-market of labor provides job seekers with the ability of quick search of a large number of employment offers. Usually, companies in the employment process prefer collecting electronic business curriculum vitae (e-CV) through e-recruitment portals (Mitrović, 2011). In this way, job seekers can leave their biographies to potential employers. Web portals can be a medium for e-recruitment of candidates suitable for a job (Unadkat, 2012). The advantages of using a portal for e-recruitment are to quickly find and obtain job information, easy and simple communication between job seekers and employers, and the possibility of employment in remote locations (Radenković et al., 2015). Furthermore, portals for e-recruitment provide more information about companies and job offers and have an advanced possibility of matching candidates' skills and job requirements.

This paper presents an e-recruitment portal. The idea for creating this portal has emerged after observing the work of Association of students of information sciences FONIS, established in 2001. on the Faculty of Organizational Sciences. The main goal of this work is developing a unique aggregator web portal that will help connect companies with students and narrow the channel by which students get the employment information.

2. MODEL OF E-RECRUITMENT VIA WEB PORTAL

2.1. E-recruitment

Before we explain the model of e-recruitment and its use, let’s revise the e-recruitment as a term. E-recruiting stands for the use of internet for attracting, recruiting, and retaining job seekers and employees and also individuals who are content in their current position (these are called "passive candidates"). Also known as Internet recruiting, virtual recruiting and online recruitment.
E-recruitment emerged as an idea in late ’90s, early 2000s with exponential growth of at home Internet usage and proliferation of dot-coms, as Betsey Stevenson explains (Stevenson, 2006). In July, 2000 Alan Kruger wrote “The Internet is rapidly changing the way workers search for jobs and employers recruit workers. The resulting speed and ease of filling jobs have significant implications for unemployment, pay and

productivity". He further concludes that those who lack access to Internet job market may suffer restricted job opportunities (Kruger, 2000).
To fully comprehend the meaning of e-recruitment let's look at the definition Lievens and Harris provide:" any method of attracting applicants to apply for a job that relies heavily on the Internet" (Lievens, Harris, 2003). This summarize the whole idea behind e-recruitment. The means, methods, approaches of this type of recruitment constantly evolve and expand, so in this paper we will focus and web portal model of e-recruitment.

2.2. Web portal as a model of e-recruitment

Model of e-recruitment via web portals represents a unique access point for e-recruitment, job seeking, information and services such as job application, FAQ, statistics, etc. The user gets access to complete their applications without the need of individual access to each of the services. The content of the portal is dynamic, updated often with search possibility.

Given the circumstances that portal models are based on attracting a great number of users by offering free content, revenue models are often based on one or combination of following models:

- Advertising. A great number of users allow the portal to sell ad space.
- Membership. Even though users get the content for free, it is possible to charge membership on certain extra content.
- Partnership programs. Users can be directed to partners websites and create income for the portal.

Beside admin users who manage the system, end users of the portal are companies and students. Because of that, the portal allows different usage possibilities. Admin users can to sign-in, manage records about the companies, job and internship ads, and applications. Admin users have a privileged access to the system, which allows them to manipulate the data within. Under the term manipulate, we consider the ability to create company profiles, keeping and managing records about applications for a certain company, as well as the processing of the applications, creating and keeping records about ads created for the company and their further management.

To a company, the portal allows logging into the system, where it shows all the records of the company, including created ads and submitted applications. Company users are allowed to create and moderate existing ads, but ads can only be submitted for admin approval.

A student is a guest user of the portal and doesn't have the possibility of logging in, because the idea of the portal is to ease the access to the given information. Portal allows guest users to see published ads with all of the provided information, perform a search with certain criteria and submit the application. As the student doesn't have their own account, further notifications and information are given through e-mail service, to the e-mail address provided in the application.

For the purpose of filtering employment information, the proposed e-recruitment portal has the following main functionalities (Figure 1):

- User sign-in
- Creating company profile
- Creating employment ads
- Editing employment ads
- Deleting employment ads
- Search of employment ads
- Creating job application
- Deleting job application
- Processing job application
- Search of job application

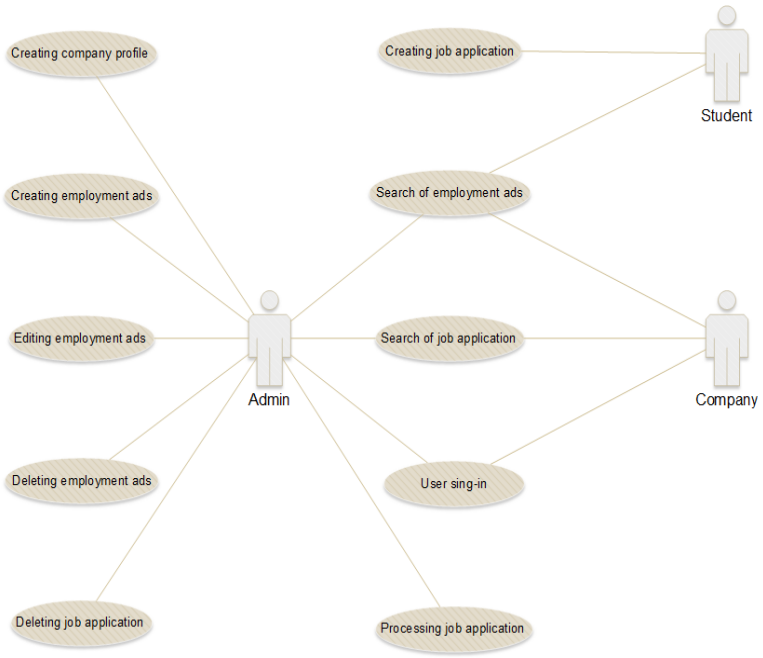

Figure 1: Use case diagram

3. E-RECRUITMENT PORTAL ARCHITECTURE

E-recruitment portal has been created using MEAN Stack technologies (Haviv, 2014): MongoDB as a database, Express.js as the Node.js (Internet 1) framework for backend and Angular as frontend of the application. MEAN Stack represents significant change in standard architecture – from relational databases to NoSQL (Strauch, 2009), from MVC oriented architectures to client single-page applications (Đorđević, 2015). E-recruitment portal architecture is shown in Figure 2.

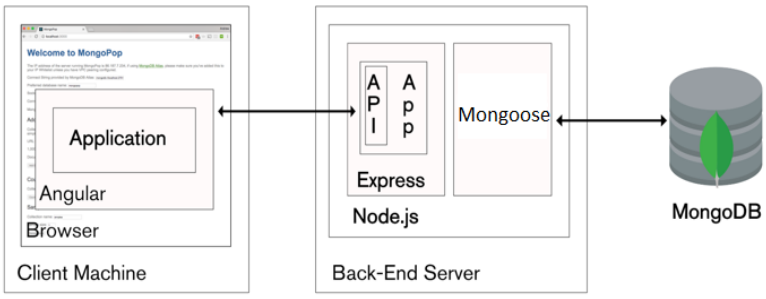

Figure 2: E-recruitment portal architecture

In the first section (on the left), the client part of the portal is shown, whose main components have been developed in Angular. It contains all UI components, all services needed for data display and sending data to the server. Server part (in the middle), is based on Node.js server, which listens to all HTTP requests. The backend of the portal consists of Node.js implemented using the Express.js framework, crucial for creating API of the portal, then Mongoose (Rahić, 2017), MongoDB tool for object modeling (MongoDB Architecture Guide, 2017), used for creating all object models used through the portal. The last part of the portal is MongoDB. It contains all collections populated by BSON documents needed for proper functioning of the portal. Collections used for implementation of this portal are (Figure 3):

1. Collection of internship ads
2. Collection of categories
3. Collection of subcategories
4. Collection of internship applications
5. Collection of users
6. Collection of messages

```
1  show collections

0.028 s   Show Profile Info

1  kategorijas
2  messages
3  potkategorijas
4  praksas
5  prijavas
6  users
```

Figure 3: List of database collections

MongoDB represents JSON documents in a binary-encoded format called BSON behind the scenes (Holmes, 2015). BSON extends the JSON model to provide additional data types, ordered fields, and to be efficient for encoding and decoding within different languages. The MongoDB BSON implementation is lightweight, fast and highly traversable. Like JSON, MongoDB's BSON implementation supports embedding objects and arrays within other objects and arrays (Leite, 2015). MongoDB can even 'reach inside' BSON objects to build indexes and match objects against query expressions on both top-level and nested BSON keys .This means that MongoDB gives users the ease of use and flexibility of JSON documents together with the speed and richness of a lightweight binary format (Internet 3; MDN, 2017). Documents are built with a name or key and value pairs. An example of one document is shown in Figure 4.

```
{
    "_id" : ObjectId("59a7dd80d8f9ba07d4f8766d"),
    "naziv" : "Angular Developer",
    "kompanija" : "Namics",
    "opis" : "Potreban nam je junior\n\nDodji i zaposli kod nas
        .\n\nOvo su ocekivanja i taskovi:\n- Writing a scalable
        app that deploys on multiple environments and has
        different themes and feature sets for different clients
        .\n- Monitoring process statuses of hundreds of cloud
        instances\n- Browsing through huge genomic datasets and
        multi-gigabyte files\n- Developing graph composition
        tools for web and desktop\n- Developing platform
        management components for bioinformatics data\n- Writing
        our own UI components",
    "pozicija" : "Junior",
    "kategorija" : "JS",
    "__v" : NumberInt("2"),
    "prijavas" : [
        ObjectId("59b000b25ac884378cc40df8"),
        ObjectId("59bef5299d32f9516872159c")
    ],
    "tagovi" : [ ]
}
```

Figure 4: Document example

4. IMPLEMENTATION OF AN E-RECRUITMENT PORTAL

4.1. Main page

The home page consists of a navigation menu, which contains a path to other parts of the application, and lists of ad practices and jobs. The main page for the guest user is shown in Figure 5 and for the administrator in Figure 6.

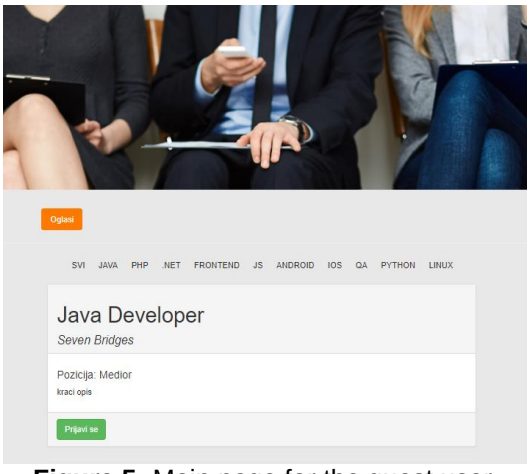

Figure 5: Main page for the guest user

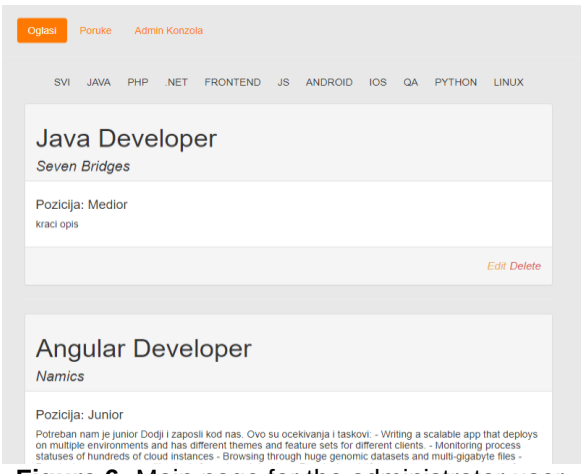

Figure 6: Main page for the administrator user

The guest user is able to search jobs using the filter shown below the navigation menu. Filters represent the categories of published jobs. Categories are set by entering ad data. A guest user is allowed to sign in to ad,

while admin or user with standard access is not. Clicking on the Login button will open the registration form within the ad itself.

The job application contains mandatory fields such as name, surname, e-mail, and link to e-CV and other optional fields that extend the application. By clicking on the button, the user sends an application for the job. The Sign in button is disabled until all mandatory fields are entered. After successfully completing the login form and clicking the Login button on the ad, the user gets a notification in the pop-up window.

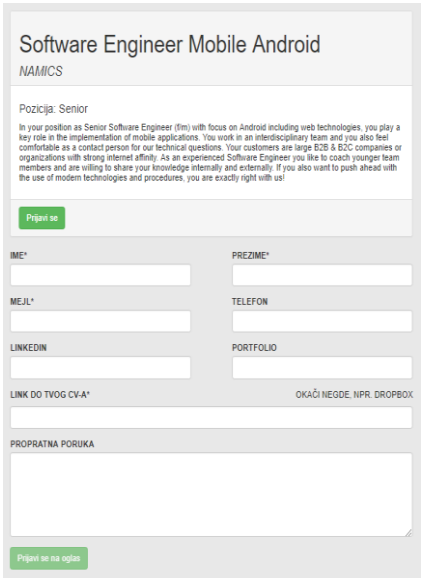

Figure 7: Job application form

4.2. Custom CMS

In order to administrator log in into the system, email address and password are required. This form is not available through the navigation menu, in order to prevent the abuse of the portal. After a successful login, the admin is redirected to the home page. The admin console page consists of a special navigation menu that contains a path to the ad management page, a login management page, a page for creating new users, and a logout page (Figure 8).

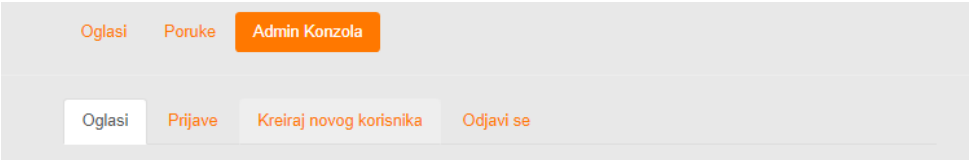

Figure 8: Appearance of a navigation user with an administrator access

4.2.1. Ad management

The ad management page consists of two parts: forms for adding new and editing existing ads, and a list of all published ads (Figure 9).

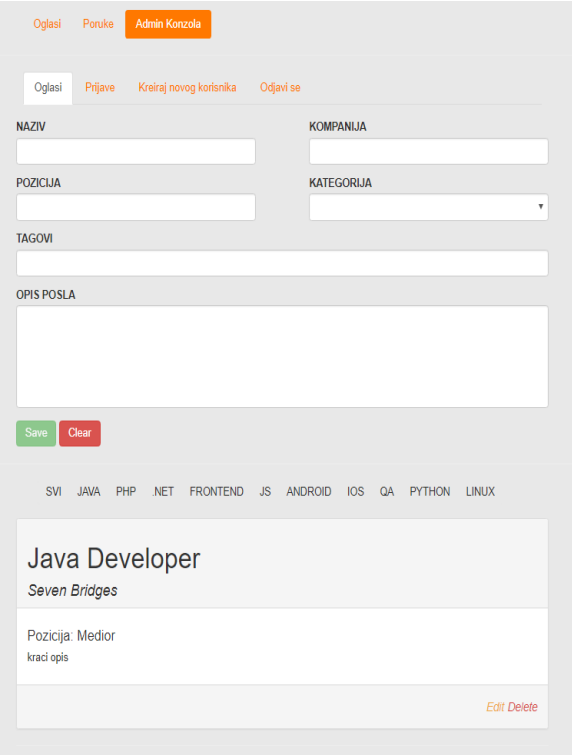

Figure 9: The ad management page

By filling out the form and clicking the Save button, the user adds a new ad to the database. All form fields are required. Fields Tags and Categories allow a search of ads. By selecting technologies in the Category field, a menu with predefined tags opens, which the user can mark (Figure 10). The Save button is disabled until all the fields are filled, which partly optimizes the validation of the form.

After successfully saving the chosen options, the user receives a notice in the form of a pop-up window. Within the ad list, each ad has the Edit and Delete option in the bottom right corner. By clicking Edit link, the form is filled in with existing ad data and editing of ads is allowed. If the user wants to delete the ad, they need to click on the Delete link, after which a pop-up window will appear where the user needs to confirm the deletion of the ad. The user is prevented from deleting ads in case that some users had applied for that ad.

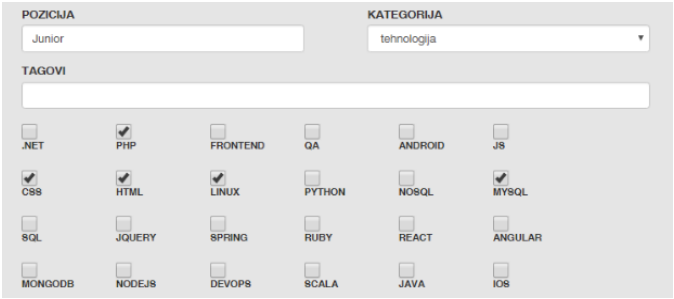

Figure 10: A menu with predefined tags

4.2.2. Application management

By selecting Login in the navigation menu, the login management page will be shown. This form contains a list of all submitted ads (Figure 11). Admin user is allowed to view and delete applications. Changing the login is not possible, in order to prevent the abuse of the platform.

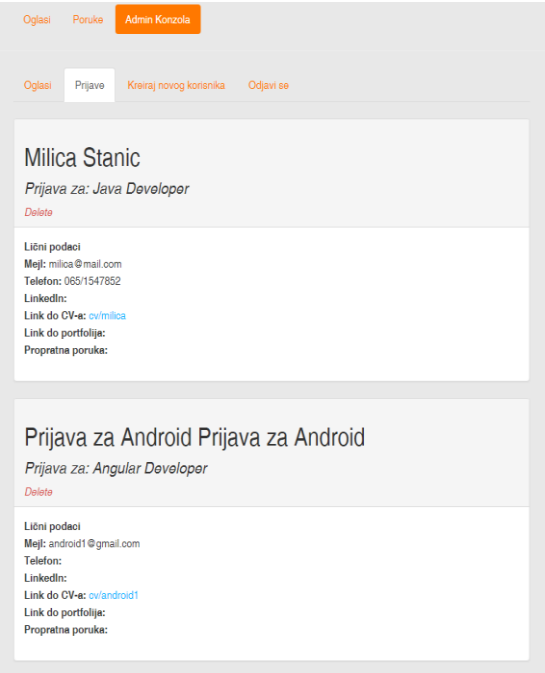

Figure 11: Login management page

Each application to the ad contains information entered through the application form and the name of the ad for which the application is filled in. To the administrator, an overview of all applications has been provided, while company users are allowed to review applications related only to their company. If the user wants to delete the application from the system, it is necessary to click on Delete in the Application header. After the user selects the option to delete, a pop-up window appears in order for the user to confirm the deletion.

4.2.3. User management

Only administrators can create new users (Figure 12). All form fields for creating a new user are required. The Submit button is disabled until all fields are filled properly.

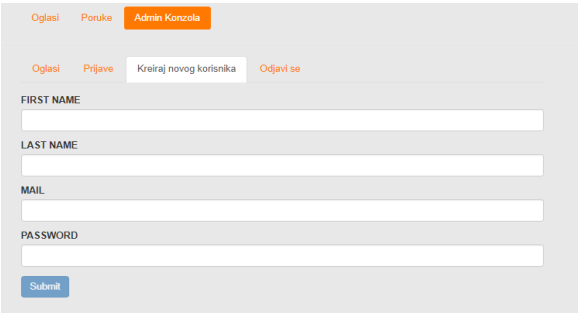

Figure 12: The page for creating new users

5. CONCLUSION

This paper presents an e-recruitment portal developed using MEAN stack technologies. The contribution of the paper is twofold. Firstly, an e-recruitment portal for advertising jobs and internships specifically to student population can make their search easier and quicker. The existence of multiple job portals and multiple channels for advertising internships make the process of finding a suitable one hard and time-consuming. Developing a portal as a service of a student organization is suitable because the students can find a suitable job or internship through a single channel. Secondly, this paper presents a case study of the usage of MEAN stack technologies for developing web portals. The choice of technologies allows an easy and rapid application development while creating a scalable and flexible application that can easily adapt to future changes.

In further development, it is planned to create a section Company in which it would be possible to search for companies ads that have created profiles on the portal. There will be an improved section of statistics in which companies can see statistics related to practices, such as the number of views, the number of applications and other. Furthermore, section Questions will show all guest users' questions for specific ad.

In order to reduce manual processing of job applications, an e-mail service will enable direct sending of job applications to companies.

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DEVELOPMENT OF AN IOT SYSTEM FOR FIRE-FIGHTING IN SMART HOMES

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***Abstract**: This paper shows an example of an IoT system for fire-fighting in smart homes. As support to this system, web application for tracking of sensors detection and warnings is shown. The devices that register smoke and flame and inform fire departments are implemented. The web application should enable early detection of fire and extinguish early fire while informing the house owner of the situation via SMS or via GSM call. All data is followed in real time through web application which is used by fire department. Aim of this system is to detect and prevent fire disasters in real time.*

***Keywords:** Internet of things, smart homes, home security, fire protection, fire-fighting*

1. INTRODUCTION

The term Internet of Things (IoT) was reportedly coined by Kevin Ashton, more than 15 years ago. The new world of IoT is creating widespread connectivity which includes devices such as cameras, toasters, garage doors, environmental and security systems inside homes and business through remote control of different sensors such as temperature, light, motion and detection (The Internet of Things and the fire service, 2017). The IoT offers promising solutions to convert conventional systems into modern ones. The technology is based on wireless sensor network, actuators, GPS and mobile devices and units. IoT is a global network of devices which communicate among each other, have their identities, physical attributes, intelligent interface and are integrated into the information network (Vujovic, 2015).

Smart home technologies (SHTs) comprise sensors, monitors, interfaces, appliances and devices networked together to enable automation and remote control of the domestic environment (Cook, 2012). Controllable appliances and devices include heating and hot water systems (boilers, radiators), lighting, windows, curtains, garage doors, fridges, TVs, and washing machines (Robles and Kim, 2010). Control functionality of these devices is provided by software on computing devices (smartphones, tablets, PCs) or through dedicated hardware interfaces (e.g. wall-mounted controls). Global consumer research carried out in seven countries worldwide, including UK and Germany, suggests a high level of market support. Over half of consumers surveyed expressed a general interest in smart homes, and 50% believe SHTs will have an impact on their lives over the next few years (GFK, 2016). Market forecasts project over half a million households in Germany will have smart appliances or devices by 2019, driven by widespread adoption of smart phones. However actual levels of uptake of smart home technologies are still low, and smart product sales are dominated by internet-connected TVs (Harms, 2015). Market growth mostly depend on users who are perceiving potential benefits and acceptable levels of risks. Smart home technologies can greatly improve energy management, security, safety, enhanced leisure and entertainment services and personal independence through healthcare provision and assisted living. (Chan et al., 2009; Nyborg and Røpke 2011). The most significant barrier to adoption of SHTs is upfront cost, privacy, security of data, reliability and interoperability of different technologies. Also there could be a social impact such as increased laziness in domestic life.

The Internet of Things (IoT) has led much of the world becoming smarter and more connected. Fire protection is among the various areas that can realize the true benefits of Internet of Things. Fire prevention and fire safety equipment are undergoing a massive revolution thanks to the Internet of Things. Internet of Things devices are connected to low power wide area or cellular networks to enhance prevention, increase response time and keep the first firefighters on the scene safe. The National Fire Protection Agency reports that 1.170.000 fires took place only in the U.S. during 2017, which resulted in 2.430 civilian deaths and $11.8 billion in property damage. Despite improved safety equipment and training, the greatest danger that firefighters face are the unknown factors they must deal with on the scene. Many departments already employ smart technology, such as thermal cameras. IoT goes even one step further, it enables leaders on the ground to see what is happening on the scene while tracking every team member's location in real time. IoT can integrate with existing alarms, personal safety devices and fire suit technology with only minor adjustments. Tracking technology keeps firefighters safer by reporting each member's exact location directly

to the shift commander, but these devices don't work using GPS technology because of its low reliability inside a concrete or steel structure. Lightweight RFID based trackers are used instead. By using the exact location and thermal cameras commander can map the area and offer guidance for other team members (Firefighting with IoT, 2017).

The model of firefighting system in smart homes is developed that should enable early prevention of loss caused by the fire and smoke. A web app should enable monitoring in real time, reducing the response time and automatically extinguishing small fires. With complete implementation of the system it should reduce costs, increase efficiency regarding the intervention, increase security inside home and improve living conditions overall.

2. LITERATURE OVERVIEW

The fire service and other emergency first responders are currently benefiting from enhanced-existing but also from newly-developed technologies. Firefighters are operating in the sensor rich environment that is creating great amount of potentially useful data. The "smart" firefighter is going to be able to fully exploit selected data and to perform work tasks in a highly effective and efficient manner (Sundmaeker, Guillemin, Friess, 2010).

Firefighting safety field has made remarkable progress in recent years in the building of information network, and has many results in application, and part of application patterns have taken shape in terms of IoT. The overall society has great expectation and demand pressure to the improvement of Fire IoT management level, and provided a great market potential for its application.
The modern firefighting system is based on wireless sensor network in combination with Internet of Things. Due to modern and advanced technology the system minimizes the losses caused by fire. There is significant variety of information accessible by fire brigades and great potential lies within Internet of Things. The Fire Protection Research Foundation's executive director Casey Grant says "Real-time information will greatly assist emergency responder situational awareness, which is especially critical during an event when time is precious" (Xin, Quanyi, 2010) .

Fire automatic alarming systems are very popular nowadays. These systems are widely used in most civil and industrial buildings in China. With only one additional internet interface and one management software in a single building, fire detection can be realized. Distant monitoring systems (DMS) are the link for to the buildings with the alarming system. Distant monitoring systems are based on modern communication network and allow real-time monitoring of all information. This is just the beginning of such systems which can be technically improved further. This improvement has been achieved by the rapid development of "Golden Shield" firefighting teams in China, by taking advantage of public security private network and specialized communication network. Progress in automatic office work, sharing and using of firefighting information as well as rapid response of firefighting teams have been achieved (Vijayalakshimi, Murugananad, 2017).

Fire protection management consists of 4 main parts:

1. Regulations - all public and some civilian buildings must have fire safety regulations in case of emergency.
2. Supervision - supervision management contains archives of fire management, fire safety inspection, fire control inspection and so on.
3. Response capacity of fire emergency - it contains response plan establishment, full-time firemen and voluntary fire brigade formation and response plan drills. Comprehensive fire emergency response plan can not only do a lot of help to assist commanders while giving commands, making decisions and deployment but also to ensure the fire officers and soldiers get familiar with environment immediately and deploy rationally.
4. Publicity and education training - building should have fire safety bulletin boards in the striking place, which disseminate fire hazards and the measures to be taken when the fire breaks out. Regular fire safety training should be organized to ensure that all occupants know the emergency evacuation process. (Ying-conga, Jingb, 2013)

Only two companies today successfully sell and implement smart IoT solutions. ZigBee and Aeris solutions are the leaders in IoT fire prevention systems. Aeris offers comprehensive solution meant to enhance security in emergency situation, and mostly prevent firefighting staff from injures or even death. The most important capabilities of Aeris' products are team members tracking in real time using the most advanced technology that is fireproof, light to carry into the scene and extremely reliable. Robotic response is another capability. These robots may be able in some cases to arrive on the scene faster than humans. They are supplied with oxygen and sensors to help and identify victims inside the fire and are able to map and clear

the rooms before the firefighters arrive on the scene. The main downsides of Aeris are price. These systems are too expensive and they still involve a lot of human interaction to function properly (Gao Y., 2016).
ZigBee technology made a revolution in fire prevention. They made five systems that can work independently or together as a single unit. It involves fire control room as an intermediary between the building and fire department. Since the fire breaks out, thermal monitoring system sends a fire signal into the fire control room of the building and activates ZigBee's hydrant extinguishing system to extinguish the early fire. When the control room confirms the disaster, a fire signal is sent to the fire department. Where ZigBee's IoT terminal is used to find the shortest route to the fire scene.

The five systems of ZigBee are as follows:
1. Thermal imaging fire monitoring system
2. ZigBee IoT alarm system
3. Wireless ZigBee fire hydrant monitoring and related technology
4. Mobile terminal information sharing system
5. ZigBee IoT terminals and radio frequency positioning rescue technology (Y.Z. Jang, J.H. Gao, 2010).

Downside of such a system is its price, even as a single system. It requires a lot of human involvement, it is not customizable enough, and it can only be implemented in the early phase of building construction, otherwise costs can be as triple as normal.

The requirements for the firefighting system monitoring developed in this paper are as follows:
- Sensors for gathering information on the scene
- Database server for real-time tracking
- Automation of extinguishing process
- Fire department and firefighting personnel

3. MODEL OF IOT SYSTEM FOR FIRE-FIGHTING IN SMART HOMES

This paper presents a system that allows early detection of fire, alarming the fire department and activating the countermeasures. The system consists of a smoke detection sensor, a temperature sensor, a flame detection sensor, a relay, a solenoid valve, GSM module, Arduino microcontroller and a Raspberry Pi microcomputer. In the case of smoke detection, the fire department is alarmed through the web application and the location and smoke pollution information is sent to the screen of the brigade in charge. In addition to informing the fire department, using the GSM module, a mobile call is placed to the smart home owner. If the situation gets worse and early fire and smoke turn into real fire, the flame detector sends a signal to the control unit that activates the relay which activates a solenoid valve. Valve brings water to sprinklers in order to extinguish fire and prevent severe damage to the smart home.

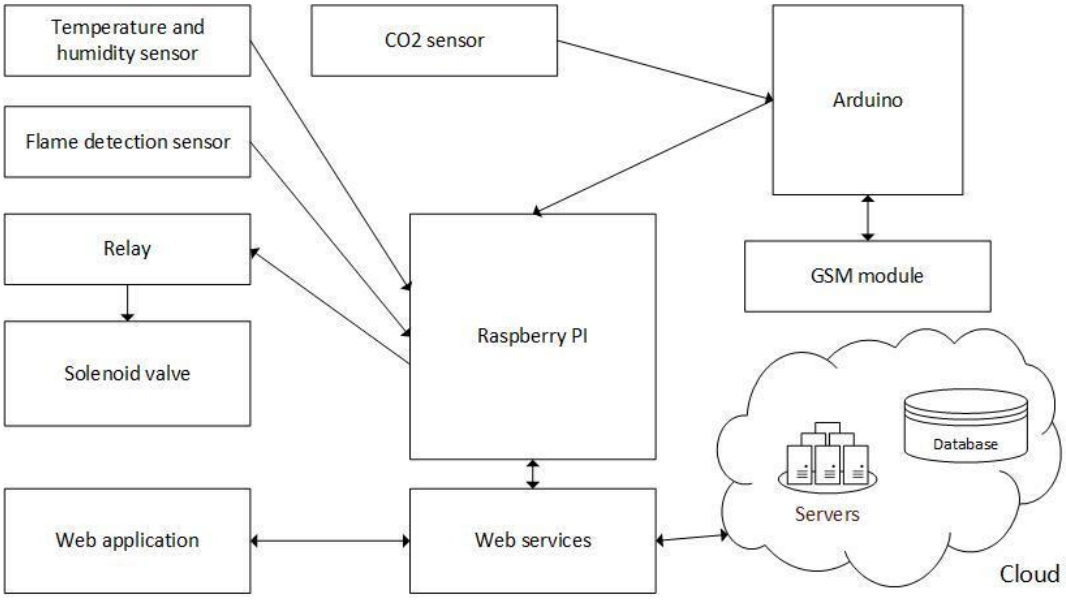

Figure 1: Model of fire fighting system in smart homes based on Internet of Things

When such events happen all information is sent to fire departments in order to improve the service and better prioritise emergency situations in the future. All necessary data is passed through a web application.

Using this kind of model it is very easy to determine levels of CO2 in the air or detect flame. This information is crucial to take next steps to protect the household and its residents. The use of this model allows complete automation of fire extinguishing. Additional information is provided by the temperature sensor and the humidity sensor. These sensors can be very useful in early detection of a fire.

Data is sent via web services to the server and it is stored in non-relational MongoDB database. MongoDB is an open-source database management system based on documents. It is classified as a NoSQL database that avoids the traditional structure of relational database-based databases. The basic structure consists of JSON documents with dynamic schema, or BSON format (binary JSON). Sensibility of the flame detection sensor is set to maximal, so it would detect any light in the room.

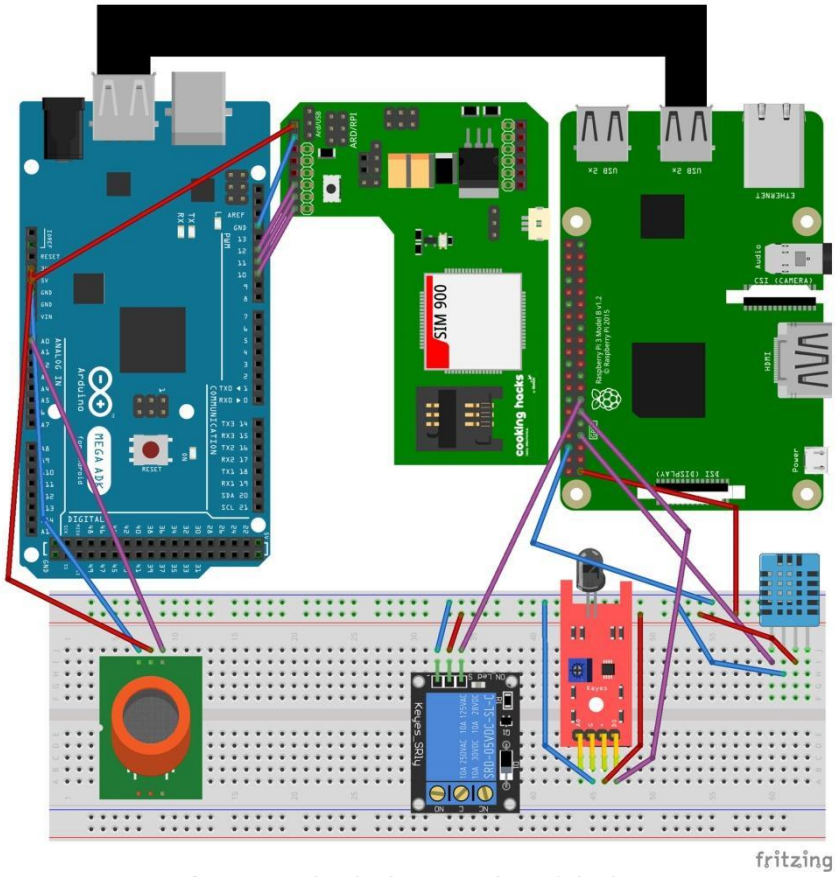

Figure 2: Physical connection of devices

On the figure 2 are shown Raspberry Pi microcomputer and Arduino microcontroller connected with sensors and actuators. Blue lines represent cables that are connected to the ground (negative pole) on Raspberry Pi. Red lines represent cables that are connected to power source of 3.3v or 5v on Raspberry Pi. Purple lines represent cables that transfer data between devices.

Raspberry Pi has a web server running. Arduino is connected to Raspberry Pi and sends data read from CO2 sensor. Temperature and humidity sensor, relay and flame detection sensor are connected to Raspberry Pi while GSM module is connected to Arduino. Because of big amount of data the non-relational database is used and it is located on the cloud.

4. DEVELOPMENT OF WEB APPLICATION FOR FIRE-FIGHTING SYSTEM

In order to implement such system in regular household few requirements have to be met. Whole house has to be covered with stable Wi-Fi connection, constant power and water supply. In addition to this requirements, the house owner should have mobile phone with GSM and SMS capabilities.

This paper presents a web application that allows firefighters in the control centre to monitor the state of carbon monoxide in smart homes. The web application is developed by using Bootstrap framework. Application logic on server side is developed in PHP programming language. Parts of the application logic which are executed on the client's side are developed using JavaScript. AJAX is used for data insight in real time. All communication with web server takes place through sending and receiving HTTP requests that carry data in JSON format.

Along with carbon monoxide information, in case of emergency, application shows CO2 level, address and option to send fire fighting vehicles to the location. Location is visualised, using Google maps as it is shown on Figure 3. Based on location, system calculates ETA by checking the location of the nearest emergency vehicle.

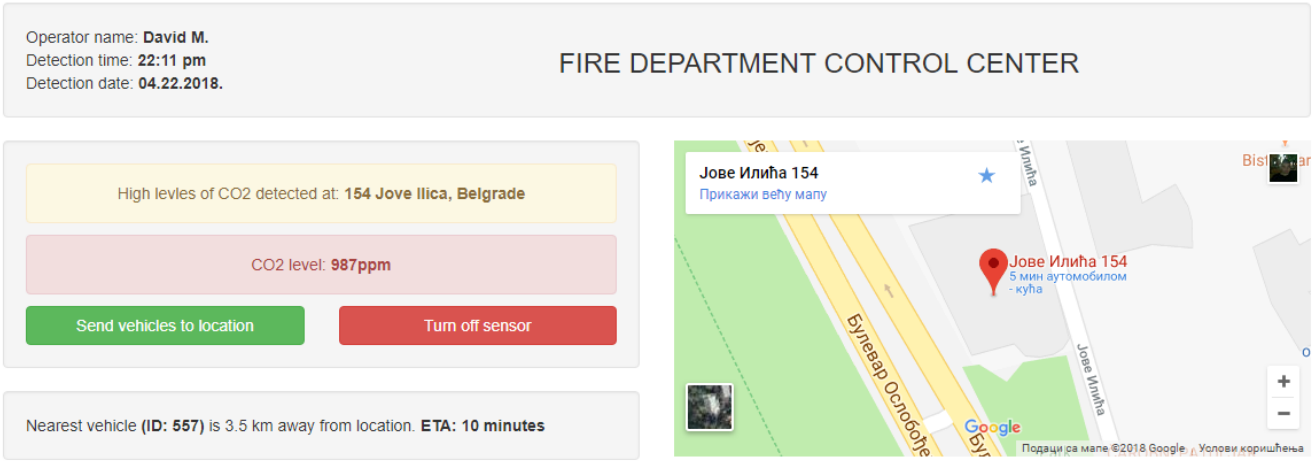

Figure 3: Fire department web application

At the same time while sending the information to the fire department, the system, uses GSM module which is connected to the Arduino and calls home owner to inform the about potential fire disaster.
As an alternative to web application it is possible to develop mobile application. Within mobile application user would have an insight to the data from the sensors inside the smart home, with some additional functions like push notifications.

Figure 4: Call initiated via GSM module

5. CONCLUSION

In this paper, development of an IoT system for fire-fighting in smart homes is shown. System was developed on Department of e-business at Faculty of Organizational Sciences, University of Belgrade. Architecture of the proposed model is defined. Furthermore, implementation for firefighting system in smart homes was presented.

Main advantages of this solution are simplicity, low cost of equipment and possibility of implementation in other smart environments like smart buildings, offices and storages. Important advantage of this solution compared to other solutions is versatility. This system can easily be implemented into civilian homes without a need for major construction works. Model can be improved with additional sensors. Expanding the sensor network will increase data collection which will lead to improvement of system precision and it will allow better recognition of early fire.

One of disadvantages of this system is that it requires advanced technical knowledge needed for implementation. In order for system to work with optimal performance participation of the city administration is needed to enable communication between smart homes and emergency services.

While other solutions mostly relays on human involvement and low automation, system shown in this paper overcomes these difficulties by using solenoid valve which is connected to water source. Solenoid valve is able to send water to sprinklers and quickly extinguish early fire, which makes it completely automated system.

Real-time data is shown inside the fire department which includes temperature, gas level, and data gathered from flame detector. This way quick intervention of fire brigade is always provided to those who need it.

This system can be improved by analysing all the collected data from sensors. Analysing large amounts of data in real time and using machine learning can allow the fire department to detect the fire before it actually starts. This new approach gives a reliable solution that can permit to detect fires risks, in order to avoid severe damage of this disaster, when it happens. Application of IoT in fire monitoring is an excellent solution that leads to smart city development.

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DEVELOPMENT OF A SMART AGRICULTURE AUTOMATION SYSTEM BASED ON INTERNET OF THINGS AND USE OF RASPBERRY PI

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Abstract: *Smart agriculture is overtaking traditional ways of food production. Modern life dictates very fast rhythm and there is not enough time for dealing with house jobs and managing a home garden. With help of Raspberry PI and Internet of Things (IoT) this becomes reality. This paper presents implementation of Raspberry PI device with the use of IoT in home conditions as well as a design of the smart agriculture system which is divided into software and hardware part. Smart sensors are also a part of proposed solution. Their usage is giving a big advantage in food production and monitoring. Temperature and humidity data are available in every moment which gives the opportunity for proper and timely reaction. Proposed implementation is given in order to provide a standard solution for creating a smart agriculture system for home use.*

Keywords*: Raspberry Pi, Internet of Things, smart agriculture, automation, monitoring*

1. INTRODUCTION

New technologies are being developed on daily basis and its usage is growing and progressing. Similar changes and innovations can be noted in food production too. If food supply is looked, It is evident that today's offer of food is quite diverse and abundant, but at the same time the risk of the unknown effects of food consumption has risen. These unknown risk factors have led to the idea of using new technologies in the process of producing and growing food in homes with none or minimum effort. As the awareness of people's health has increased in recent decades, most people began to take care of their nutrition. Although the supply of various foods is high, today, in most cases, consumers do not know what they are actually buying and whether the food is contaminated with some harmful ingredients that could endanger their lives. One of the solutions to this problem is that people produce organic food that is part of everyday nutrition for themselves. Although this process requires a lot of time, the development of IoT and connected computers and various sensors, allows that most of the process of growing the plants can be automated, whilst saving a large amount of time. One type of computer that uses its application in diverse number of spheres, because of its compatibility and price is Raspberry Pi.

This paper describe implementation of Raspberry Pi computer with the use of IoT and smart sensors in home gardens. Connecting and programming a smart agriculture system is not so hard and provides a lot of benefits for their owners. The number of these systems will be increasing over time.

Paper is organized as follows. After the introduction, Section 2 is devoted to literature review and description of used hardware and technologies. Section 3 refers to use of Raspberry Pi in general, and especially in smart agriculture. Design of the smart agriculture system which include main objectives, hardware and software architecture of the system will be presented in the Section 4. Implementation of the presented smart agriculture system will be explained in the Section 5. The conclusions and directions for further research are given in Section 6.

2. LITERATURE REVIEW

"Internet of Things" represents an inter-networking of various physical objects, vehicles, buildings and other devices with embedded electronics, software, sensors and connectivity that allow objects to collect and share data (Brown, 2016). IoT allows objects on the network to be viewed and controlled remotely, with the aim to create a more direct integration of the computer system and the physical world (*Harvard Business Review, 2016; Vermesan and Friess, 2013)*. In this way, with the reduction of human intervention, greater efficiency is achieved, along with the accuracy and economic benefit. The whole structure of Internet of things, in order to do a simpler analysis and design, can be divided into three parts or levels: hardware, infrastructure, applications and services. The first and lowest IoT part is hardware for connection of physical devices. Only those devices that are connected can share information and learn from experience. The goal of this part is to build devices and systems with built-in computer functionality and intelligence for proactive

thinking and behavior. Infrastructure as the second IoT part allows devices to connect to a wireless or some other computer network. This connection should enable an environment for development of IoT applications through channels for information and device information management and decentralized management channels. The third and highest IoT part are applications and services for obtaining data from the device, processing and delivery. Improvement of this applications and services is necessary for development of smart environments and the meaningful application of IoT in different areas. (Radenkovic et al, 2017)

In recent years, the development of information and communication technology (ICT) resulted in the emergence of two important concepts that affect the world around us: Internet-of-Things (IoT) and Cloud computing (Ashton, 2009; Evans, 2011; Mell and Grance, 2011). Innovations have improved capabilities to precisely monitor environmental conditions and to make proper actions according to received data. In last few decades, people are becoming unnecessary for more and more things everyday. Machines, robots and computers with the use of modern technologies are present in every branch of the ecomony.

The literature concerning issues related to automation of home gardens and use of Raspberry Pi is extensive. One of the first papers that present the use of wireless sensors and use of new technologies in agriculture is presented by Wang et al, (2006). Wireless Sensor Networks (WSN) are widely used in monitoring and predicting of data in agriculture business. WSN system construction and its implementation in agriculture for growing a roses is presented by Rodriquez et al, (2017). Detailed description of nanostructured (bio)sensors for smart agriculture is presented by Antonacci et al, (2018). Authors (Schumann-Bölsche and Schön, 2015) are considering applying of Raspberry Pi and sensor technology to some parts in Africa in order to help and improve their humanitarian logistics. Precision agriculture application with a cost effective and standardized sensing system for remote monitoring and disease monitoring is presented by Sawant et al (2017). A case study for a private IoT enabled platform for research in precision agriculture and ecological monitoring domains is presented by Popovic et al, (2017). Authors (Mohanraj et al, 2016) proposed the advantages of using new technologies in Indian agricultural sector, which enables the rural farmers to replace some of the conventional techniques. Large field monitoring was unthinkable until recently. Automation of large field monitoring with the use of sensors and Raspberry Pi is presented by Balamurugan and Satheesh (2017). In order to get a desired quality of wine, Morais et al, (2018) designed, developed and implemented monitoring system in order to measure wine temperature, pH, redox potential and wine's dissolved oxygen. One of the review papers that offers IoT applications in agriculture is presented by Talavera et al, (2017).

In literature, can be found a lot of papers with implementation of such infrastructure in various fields. One of them is application of IoT with the use of Raspberry Pi for creating a renewable energy monitoring system (Pereira et al, 2018). On the other hand, Perumal et al, (2017) used Raspberry Pi for monitoring building system. Building monitoring system is consisting of monitoring power consumption, temperature, light and humidity. Some authors (Vujovic and Maksimovic. 2015) suggested use of IoT and Raspberry Pi for automation of homes and buildings in order to discover fire. Also, one of the implementation is done in biometrics (Shah and Haradi, 2016).

3. RASPBERRY PI IN SMART AGRICULTURE

Raspberry Pi is a single-board computer, with the size of a credit card, developed in the United Kingdom with the intention of promoting basic computer skills and sciences in schools and developing countries. Although primarily developed for educational purposes, due to its portability and the ability to interact with the outside world, Raspberry Pi became very popular and began to be used for various purposes.
A large number of developers and applications use Raspberry Pi for home automation. These developers are trying to modify the Raspberry Pi and make it a very affordable solution for monitoring energy and its consumption. Due to the relatively low cost of this computer, Raspberry PI has become a popular and economical solution, in contrast to more expensive commercial solutions (Rao and Uma, 2015). As Raspberry Pi is popular in a large number of different spheres, it has found its application in agriculture as well. A great deal of significance has been contributed by a huge number of sensors, such as temperature, humidity, soil moisture sensors and many others that can make a big contribution to the improvement and automation of agriculture.

"Smart agriculture" based on IoT technologies enables farmers and manufacturers to reduce investment time and increase productivity by controlling the quantity of fertilizers, controlling irrigation, regulating temperature, etc. In IoT based smart agriculture, a system is built for monitoring the crop field with the help of sensors and automating the irrigation system. The farmers can monitor the field conditions from anywhere. IoT based smart farming is highly efficient when it is compared with the conventional approaches.

The application of smart IoT based agriculture doesn`t have to target just large agricultural corporations, but also can be new starter for rising trends, such as organic production, family farming and many others. When it comes to environmental issues, smart IoT based agriculture can provide great benefits including more efficient water use as well as optimization of inputs and treatments.

4. SMART AGRICULTURE SYSTEM DESIGN

The impression is that people have recently raised their awareness about healthy eating habits, but still they are not sure whether healthy foods that are marketed are actually "healthy". In this case, the only solution is the independent production, where it can be known for sure the origin of the food. One of the difficulties for that scenario is the necessary time to dedicate for something like that. Solution to this problem is a smart agriculture system, which will automate process of monitoring the condition of crops, collecting and process data, together with the automation of individual processes such as irrigation. The goals that automated smart agriculture system needs to fulfill are:

- Management of the agricultural land without electricity,
- Automated soil irrigation,
- Preservation of temperature and humidity data on soil

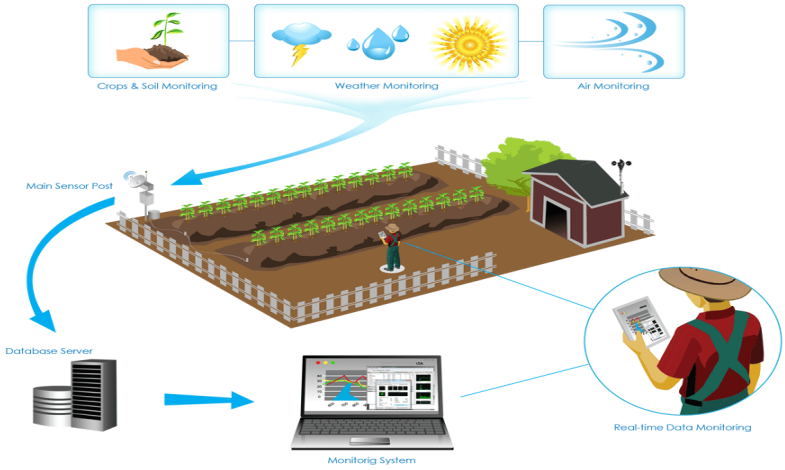

Figure 1: IoT system for smart home gardening

In order to accomplish these goals, it is necessary to use different types of smart sensors along with Raspberry Pi. Smart sensors are devices which interact with physical environment. Received environment inputs then use built in computer resources of sensor to perform some of the predefined functions at the moment of input detection. The collected data is first processed and then forwarded. As the basic integral element of Internet of Things, smart sensors manage to improve the accuracy of collected data from the environment and make this process automated. Smart sensors, combined with other components such as amplifiers, converters and analog filters are used for control and monitoring mechanisms in different environments. Management of the garden without electricity is enabled by using a solar panel that is connected to a battery which is a power source in smart agriculture system. In this way, it is enabled to install this system in places without the possibility of connection to the electricity. As timely watering is one of the most important processes for breeding the plants, drop by drop watering system is the one that has proven to be very efficient. This system is used in most cases. The name "drop by drop" tells us that it is a system that pours every plant equally. Electro valve is a valve in which water flow can be regulated with use of electricity. Also, this system can be used for feeding the plant, if a tank from which irrigation water is used supplies certain fertilizers that promote the growth and health of the plant. In order to track the humidity and soil temperature, it is necessary to integrate smart sensors.

Smart agriculture system design can be divided into hardware and software part. The hardware part represents the infrastructure that consists of inter-connected physical devices, such as source of energy, which is in this case a battery powered by a solar panel, pipes for soil irrigation, smart sensors for measuring humidity and temperature of soil as well as automatic irrigation valve and Raspberry Pi as the main device in the system. All parts of the smart system are connected to the Raspberry Pi with its GPIO pins for collection of inputs. When the infrastructure is set up and connected, in order to allow for the collection and processing of data from all devices of the system, it is necessary to program Raspberry Pi. By developing an APIs for collecting data from different devices, it is possible to undertake certain actions in automation process. The

SIM card implemented in the Raspberry Pi is used to manage the system from remote devices such as home computer or a mobile phone.

5. SMART AGRICULTURE SYSTEM IMPLEMENTATION

Implementation of smart agriculture system is main goal of this paper. The implementation can be divided into several steps, such as preparing the ground, setting up energy sources, setting smart sensors and linking them to Raspberry Pi, as well as programming it in order to collect and process data.

In the first step, it is necessary to prepare the arable surface by installing the pipes for automated water irrigation. In length, with a meter distance between them, pipes are implemented. The arranged pipes are connected with the water source, precisely one hundred litres barrel. On the connection with the barrel, 12V electric valves are installed. Their purpose is to regulate the soil irrigation and automate it using Raspberry Pi. In order to secure the power source, solar panel is placed at the appropriate place to collect solar energy. The solar panel is then connected via controller to the 12V and 100Ah battery that is a power source of the smart agriculture system. The sensor for measuring the temperature and humidity of the air is set to the meter from the ground level, while the sensors that measure the condition of the earth, are placed directly into the soil, closer to the plants, in order to have accurate information. Humidity and temperature sensors are an indispensable item for keeping records and analyses for some future ventures that can comprise a larger amount of plants. The DHT11 sensor is digital sensor for measuring temperature and humidity. SparkFun Soil Moisture Sensor is the analogue sensor for measuring soil moisture. DS18B20 is digital waterproof sensor for measuring soil temperature. All of these sensors are connected to Raspberry Pi by cable and "breadboard", while they are connected to the battery to receive a power source.

Figure 2: Sensors for implementation an IoT in smart agriculture

When everything is set up and properly connected to Raspberry Pi, it is necessary to "program" Raspberry so that the data is collected and processed and so that can later help in undertaking certain actions. The mentioned data is collected with the use of GPIO pins. Each sensor has at least three outputs, such as electricity, grounding and data output. The last one (data output) is used for connection to the mentioned GPIO pins of Raspberry, which can enable quickly data collection and processing by the Raspberry. Since the Linux operating system is used on Raspberry Pi, the python programming language and the Flask framework for routing are used in order to enable the server to collect and process data from a Raspberry. This server contains five methods:

- get_temperature
- get_humidity
- get_soil_temperature
- get_soil_moisture
- do_irrigation

get temperature is a method that returns the current temperature in the json format {'current temperature': 20}. get humidity is a method that returns the current air humidity in the json format {'current humidity': 49}. get_soil_temperature is a method that returns the current soil temperature in the json format {'current_soil_temperature': 29}. get_soil_moisture is a method that returns true or false depending on whether the earth is moist or not. do irrigation is a method that takes time in minutes as the input parameter for irrigation of plants.

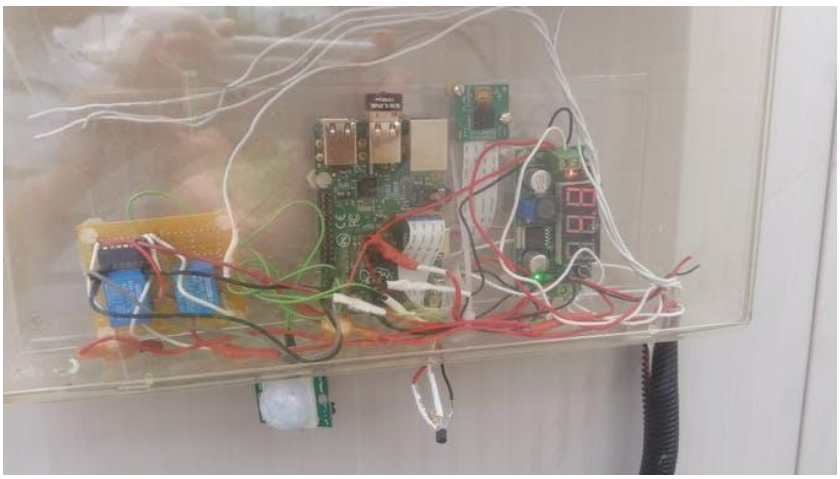

Figure 3: Connection of Raspberry Pi with sensors and controllers

For further management of the smart garden, it is necessary to install an application in order to get information's about the current vegetable state and plants in generally. This application is not something that should be complicated, instead of simple, transparent and easy for use application. It can be "One page" application that gives all the necessary information in one place, so it can be helpful with making conclusions on what is happening and eventually to help with prevention of some possible losses. This application will have two tasks:

- to provide real time information on temperature and humidity of soil at any time, as well as a button for regulation of irrigation that can be either automatic or manual (automatic means that whenever the land is dry system for irrigation is turned on for 10 minutes)
- to store collected data for temperature and humidity of soil in the database on every half hour, so it can be used for further analysis and preparation of bigger projects.

Also, it is possible to ensure that the collected information's are sent as a SMS.

6. CONCLUSION

Monitoring of temperature and humidity of air and soil with the use of IoT is definitely the future for either home gardens or for bigger projects and farms. Necessary actions in case of a deviation from normal values are covered. It is evident that Raspberry Pi is bringing so much advantage in smart agriculture and producing of organic food in home conditions for personal use. The same technology can be applied to large-scale gardens in which organic foods can be produced in order to find their place on stalls across markets and green markets. Implementation of smart agriculture system with the use of Raspberry Pi and IoT is presented for personal and home use. Evaluation and comparison between traditional production and technology monitored production as well as possible advantages of using blockchain technology are set as a goal for further research.

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DEVELOPMENT OF AN EDUCATIONAL GAME: AUGMENTED REALITY APPROACH TO EDUTAINMENT

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Abstract: *In this paper, the authors examine the problems, capabilities, and benefits of implementing augmented reality technologies in higher education and integrating them into formal e-learning in the form of edutainment. The main goal is to design and develop an educational interactive game that features augmented reality and would enrich the teaching process with interesting content as well as motivate students and stimulate their acquisition of knowledge. The developed game is based on current internet mobile technologies, with AR aspects realized through the use of the Vuforia platform, and is implemented as a part of a smart classroom. It includes a web application for teachers to create tasks, small parts of the curriculum that are being tested, a mobile application that students use to interact with the game and solve tasks, an augmented reality module that supports distance learning and a component for integration with Moodle LMS. This paper will focus on the AR aspects of the game and the benefits that can be gained with its use in education. The game has been implemented within the educational process at Faculty of Organizational Sciences, University of Belgrade*

Keywords: *Augmented Reality, Internet of things, game-based learning, edutainment.*

1. INTRODUCTION

The educational process is ever changing and evolves over time. This progress stems a requirement to fulfill the needs of the students that change over time (Education, 2011). With the coming of the digital age and the daily innovations which represent it, it has never been harder or more important to redesign current methods of teaching and formulate a new approach that will accommodate a society living on the thin line between the real and digital worlds (Bowen, 2015). There is a need for modern education in all age groups with special focus on children starting their education as they are a generation born into the modern world and are introduced to many forms of technology since birth (Yelland, 2006). Technologies of augmented reality in education are increasingly being used and show great potential and contribution to the teaching process from the pedagogical aspect.

Many innovations in education come from the constant rapid development of Informational and Communicational technologies, especially Internet (Gyorgy, Suciu, Alexandru, & Militaru, 2014; Labus, Despotović-Zrakić, Radenković, Bogdanović, & Radenković, 2015). The effects of implementing internet technologies in e-learning have been a focus of many studies (Means, Toyama, Murphy, & Baki, 2013).

There are numerous articles and research papers with incorporating smart technologies or new methods in education as their focus of attention but a lot of them approach the subject matter from a purely theoretical view (Cook & Das, 2004) while other works don't always demonstrate the full integration of game-based learning in conventional education systems (De La Guía, Lozano, & Penichet, 2013; Kipper, 2013; Shen, Wu, & Lee, 2014). In this research, we try to contribute to filling this gap by developing a game within a smart learning environment and that aims to enhance the user's perception by utilizing the power and popularity of augmented reality.

2. LITERATURE REVIEW

A. Augmented reality

Augmented reality is a technology that has an astounding number of applications such as business, medicine, gaming and other forms of entertainment and education (Liou, Yang, Chen, & Tarng, 2017). Using AR in educational games leads to hybrid games, games in which digital and physical objects can interact with one another (Mircea et al., 2011). It is a new medium, combining a multitude of different computer aspects to offer a unique approach to continuous and implicit user control (Lee, 2012). This approach can enhance the quality and speed of training by providing a different view into the subject matter (Kamphuis,

Barsom, Schijven, & Christoph, 2014). An example of this is the use of AR in medical training (Gu & Duh, 2011). By switching from 2D images to 3D models generated by smart devices, medical students can better grasp the concept of many elements in their field of study like anatomy. Advances in mobile devices and their graphics processing and rendering increases the gaming potential of mobile phones . By combining mobile 3D game engines with Augmented Reality technologies it is possible to create a platform that is capable of enriching our reality any time any place. One such example is described in (Sherstyuk, Vincent, Berg, & Treskunov, 2011). In this example, authors describe the process of interacting with a 3D model of a patient. Thanks to mobile technologies, the model is not only rendered in 3D it is also responsive and fully functional. In this way, many hardware limitations of physical tools are circumvented and students are capable of gaining practical knowledge in a far greater capacity.

Currently, most of the innovative approaches to education are implemented as part of higher education. This is because universities have the necessary technologies and skilled personnel that are not only capable of conducting such classes but also willing to research new approaches to teaching (Begg, Dewhurst, & Macleod, 2005). That being said, it isn't restricted to universities as there are attempts to do the same on a high school level (Papastergiou, n.d.).

B. Educational games

Studies have shown that there is a great need for a better way to provide education. Due to rising demand for highly educated people, educational institutions cannot provide the necessary supply. This leads to creating more efficient means of teaching that can speed up the process and increase its quality (Savander-Ranne, Lunden, & Kolari, 2008). Many studies have shown that alternative and modern approaches to teaching yield better results (Stojanovic, Bogdanovic, Nedeljkovic, 2016). Some of the techniques that have been recently looked into are the use of modern technologies in the form of teaching tools and the use of edutainment in the teaching process (Knežević, Despotović-Zrakić, Labus, Jezdović, Ivković, 2016). Educational games find themselves used in research papers more and more and their potential is heavily discussed. They are interesting to students and possess the ability to motivate them beyond normal lecture capacity. This makes researchers explore their beneficial influence on the learning process (Petrović, Jezdović, Bogdanović, & Despotović-Zrakić, 2017). Use of games to facilitate learning is not a new concept and was used for a long time. The first form of such games is physical games. These games use physical objects to bring knowledge to students (Zagal, Rick, & Hsi, 2006). Since then, educational games have come far. Innovations in technology have created new forms of games that follow the trends and maintain their appeal to a younger audience, with the latest trend being mobile and AR games (Gros, 2007). Using video games in a teaching environment is nothing new (Alshanbari, 2013). Studies have shown that playing video and computer games can have a positive effect on players' cognitive abilities like decision making, speed thinking and reaction speed (Prensky, 2003). Another aspect of gaming that can be used to facilitate better learning is competitiveness. The competitive side of gaming leads to better motivation and a greater amount of effort being poured into performing actions whether they are of educational character or not (Burguillo, 2010). They also help focus attention to a single point which can be used for a more effective transfer of knowledge, with lesser losses of information due to "white noise" of distracting happenings all around us (Griffiths, 2002). In psychology, the greatest form of this is called "flow" and it describes a state of full immersion into an activity that focuses all of a person's concentration into a single goal (Csikszentmihalyi, 1975b, 1975a). When used in conjunction with gaming and "flow", education can be an interesting, motivational, immersive and above all else a productive activity, for example, a goal-driven educational game (Kiili, 2005). Using new technologies to change traditional types of games and adapt them to new trends makes them more interesting to newer generations and increases their effects (Petrović, Stojanović, Labus, Bogdanović, & Despotović-Zrakić, n.d.)**Error! Reference source not found.**. With the development of 3D games, we can see a rise in their popularity over the 2D type (Koops, Verheul, Tiesma, de Boer, & Koeweiden, 2016).

There are several parameters that can be used to evaluate the quality of an educational game (Aslan & Balci, 2015):
- Acceptability: the level of completion of the learning goals;
- Challenge: the level of motivation;
- Clarity: the level of understanding;
- Interactivity: the level of interaction between the student and the game;
- Reward: it enables the student's satisfaction after the completion of goals.

C. Internet of Things

Internet of things has found itself being used for various purposes, like traffic, data analysis and for our purposes the most important one of all – education. There can be many implementations of IoT in education but the most often example is in universities.

Many classrooms today are connected to the Internet and have the advanced technological equipment, such as tablets or interactive boards. This type of classroom is called the smart classroom (Song, Zhong, Li, Du, & Nie, 2014). These classrooms are equipped with all kinds of tools and technologies necessary to provide an enhanced learning experience that builds on top of the classical face to face model with a virtual, off-site approach by providing a flexible and inspirational environment (Mikulecký, 2012). These classrooms are the ideal place to implement educational games as they meet the necessary technological requirements (Xiliang, Xin, Yafei, & Mengkun, n.d.). By relying on the recent internet and mobile technological boom, limitations of smart environments are pushed even further. Using smartphones, as they are currently the equivalent of a pocket-sized computer- a fact that was unimaginable even as recent as 10 years ago, learning can happen everywhere, physical presence can become a thing of the past (Suo, Miyata, Morikawa, Ishida, & Shi, 2009).

3. DESIGN

A. Project requirements

The goal of our study was to create a tool that would transform the antiquated teaching mechanics into an exciting and immersive experience as well as monitor the effects it has on the student's motivation and knowledge acquisition. During our research, we have explored the processes of envisioning and designing methods to bring our idea into fruition as well and developing hardware and software components based on current technological standards that are necessary for implementation into a real environment. Based on its potential in education, augmented reality technologies have been chosen as a core of the solution. The result was an educational game based on AR that test's the players' knowledge on a given subject in a fun and inviting manner and monitors their progress and achieved results. The game aims to motivate students to embrace learning as a positive influence in their life by presenting it as a challenge set on a medium that the user is already accustomed to.

B. Game concept

The concept of the game revolves around the process of giving the correct answers to given questions. What differs in comparison to a standardized test is the way in which the examinees not only solve the problems but also the method of submitting their answers. By designing questions in an interactive way that forces the students to apply their acquired knowledge in a practical manner that is both fun and educational, tests can be taken to a new level. One approach to this is creating workstations or polygons for each assignment and distributing them to remote locations. This creates a goal-driven approach or in game terms manifests the illusion of "quests". Polygons can consist of any number of elements, from simple images to be used with AR modules to IoT infrastructures that demonstrate some core features of smart objects. Another approach might be through a computer or in recent times mobile education, with apps instead of pen and paper. This too can test both the theoretical knowledge i.e. quizzes or simulate some real-world situation for the student to manage. Our approach was a mixture of aforementioned solutions joined together, a model that is composed of a server which represents the core of the system and many distributed platforms made for solving each task in a different way, but obeying the standards of the central unit and integrating into it.

C. Architecture

The architecture of the developed system is shown in figure 1. The system is split into core and distributed elements with a middleware to connect them much like a bridge would. Among the core elements, we have a virtual machine to house the central web server. The server host many items that are integral to the system such as an administrative tool in the form of a web application that is used by a teacher to administer the whole testing and grading process. The most important part of this tool is to create the logical form of assignments that are presented to students during testing as well as serving as building schemas for their physical representation. Other components that make the central server their home are the main database used for storing all transactions and the many web services used by all of the system's various components. It is the services that are the gateway between the centralized core and the distributed network of participants and locations. The most important tool from the aspect of the player is the controller. Representing the middleware, the controller serves as a means of communication between the player and a black box that is the game. It is present in the form of a mobile application on a smart device such as a phone or tablet. Using its User Interface it can collect input from the user and has integrated features to connect to the APIs of the server and physical data of the environment. The last segment of the system is a collection of the many distributed locations, mostly smart environments adapted for the purpose of solving at least one task. Communication between components is realized through the use of web services, RFID tags (Miglino, Ferdinando, Fuccio, Rega, & Ricci, 2014), and QR codes (Kan, Teng, & Chen, 2011). User management and grading are interconnected with Moodle LMS.

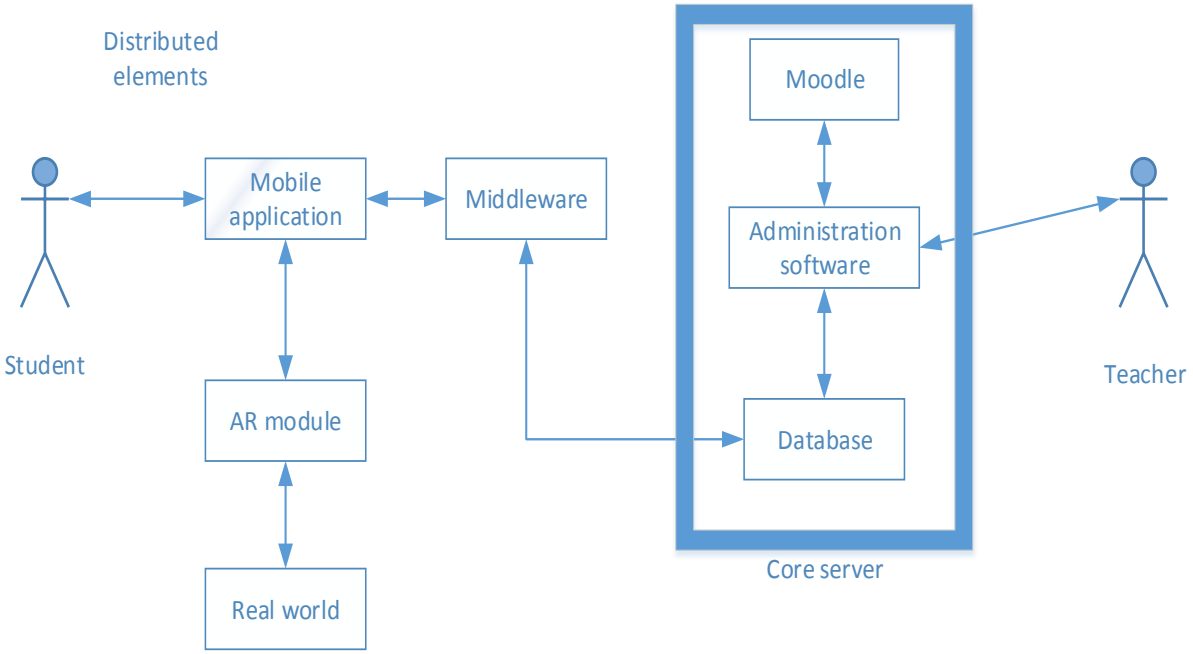

Figure 1: The architecture of the game

Mobile application

The mobile application is the player's gateway into the complex system of the game. It is the only way to interact with the physical objects necessary to solve tasks as well as the only interface that receives tasks from the server. In order to accommodate a wide range of task types, it uses task metadata to adapt to the current type and generate only the capabilities necessary at the moment (Simić, Despotović-Zrakić, Labus, Radenković, Bogdanović, 2015). It does this by being split into modules that are used as building blocks to form a whole during the loading of a new task, as seen in figure 2. The application can be divided into two parts, the Vuforia part, that enables the use of augmented reality, and the Android part that facilitates everything else.

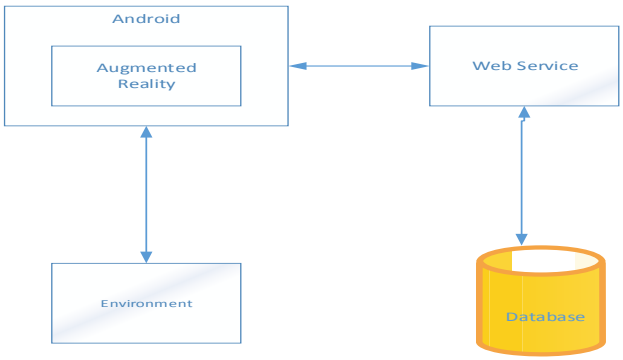

Figure 2: Mobile application structure

Augmented reality module is used to enhance the user's view of the real world and it does so by interacting with a camera view and analyzing every frame, trying to find a designated image within it. If an image is recognized 3D elements are overlaid over it. There are three types of AR modes available:

- Cloud Recognition which holds all target images as well as metadata files in a cloud server. This mode recognizes a target and reads the accompanying metadata file. This file contains names and positions of 3D models that should be rendered.
- Virtual Button which recognizes only a single target but in exchange supports user interaction. On successful target recognition, first of a list of 3D models is rendered as well as 2 buttons, left and right. When hovering underneath a button, the displayed model is changed either to the left or right of the list position of the previously displayed model.
- Explore which works similarly as Cloud Recognition in that its targets and metafiles are stored in the cloud. The main difference lies in views rendered on recognition. Unlike the first type, Explore only has 1 model available, a text panel and title and text that are displayed inside it are contained in metadata text files.

To successfully implement the game, it is necessary to prepare an environment for it. At the very least it is needed to prepare a location for all the image targets present. If there is a need to also collect data from the environment in some way, this environment includes workstations on multiple locations and equipment for students (Petrović, Jezdović, Stojanović, Bogdanović, & Despotović-Zrakić, 2017)45].

Workstations are equipment present on site for each task. If the task is envisioned to be solved with the aid of external factors and devices, then all the necessary hardware and software must be set. Since the game is played in multiple locations, they are scattered throughout the envisioned playing field.

Location of each task can be anywhere, in the classroom, in the faculty building, or outside. For example, a task can be related to measuring the temperature, and the equipment can be placed in a classroom. Or, a task can be related to plant watering, so the workstation will be placed in the garden.

Administration software

The administrative tool is used by teachers to organize tests (playing of the game), to create new tasks or modify existing ones, review achieved results for a given student and grade them. By using this tool, we prepare data that is available to other parts of the system through our web services. In figure 3 we can see the screen used for reviewing achieved results.

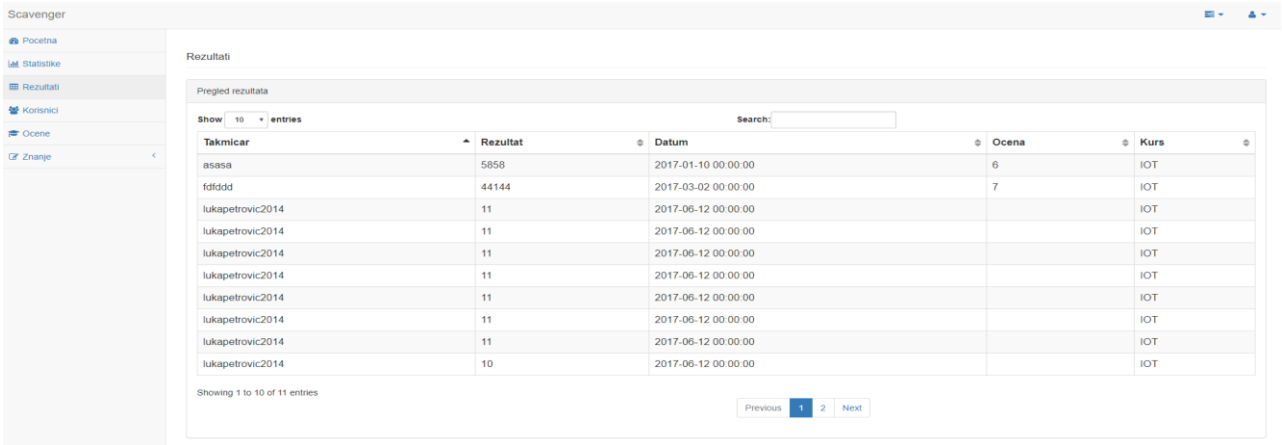

Figure 3: Results overview screen

Moodle integration

In both the mobile and web tools authentication is done via Moodle. By entering credentials a call to a public Moodle API is made with a request for authentication tokens. Only after confirmation of identities has taken place users can begin their work. Another call to the Moodle service is activated after the game ends. The client application sends the achieved results to the server for professors to grade with the help of the web application. After the grades have been set, they are set as Moodle assignment scores.

D. Game scenario

The test is split into groups of 1 or more assignments, let's call them subjects. The students, or in this context players, are given a mission to clear as many subjects as they possibly can within the time limit. They are given assignments in sequential and random order with questions from all subjects mashed together. To complete the subject, students are required to correctly answer exactly 1 assignment from that subject's subset. Once an answer is submitted its validity is put to the test. A correct one will award the player full points for that question as well as mark the subject solved. Any subject that is marked as solved will no longer be among the possible questions for that student. On the other hand, if the answer was not correct, there is no change and players are given the next task. There is no direct penalty for solving a task incorrectly as it might be received and correctly solved at a later point in the game, however, the time required to redo it decreases the acquired points at the end of the game (as the remaining time is part of the grade). New tasks are generated from a collection of all assignments from the unsolved subjects so in the case of a wrong answer the user can get that same question, another question from the previously tested subject or a question from a completely different subject. A potential penalty occurs if the player cannot correctly finish a task even after multiple attempts. In this scenario, not only is the utilized time deducted from the score, so are the points that each completed task brings.

To begin the game, students have to go to the predefined start location and acquire a player controller that is already configured. After imputing their credentials and successfully logging in to their Moodle account, they proceed to choose the option to begin testing. After starting the game, the timer begins the countdown. By

getting random tasks, students are sent to different locations and their paths diverge from the start. Next is the process of solving tasks one by one in a similar fashion until a task from each group is solved or time runs out. Each assignment has information that it presents to the player by displaying it in the controller at the moment it has been received. Among the info present is the location which the player has to go to, the question which needs to be answered as well as metadata needed to generate all the necessary components. Metadata is used to generate user interfaces that the player sees, such as the way of inputting the solution (keyboard, RFID tag, QR code) or interfaces for connecting to the environment (AR, IOT…) After arriving at the specified location, students proceed to interact with the environment in a way defined in the text of the task and its metadata. Productive interaction will yield data necessary to complete a task prove mastery over the subject. Each task is also scored according to the difficulty of completion. Completing harder tasks rewards more points but it may cost more time. The final score of the test is determined by the number of subjects closed, difficulty points of each task and the remaining time. As previously stated, the game is played in iterations, which is shown in figure 4.

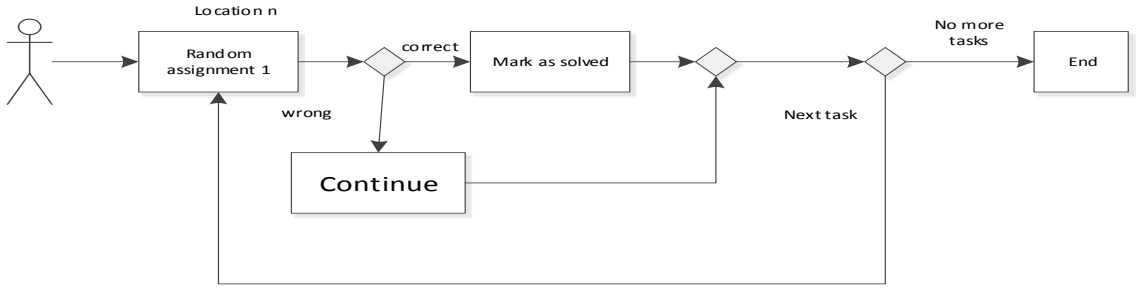

Figure 4: The game scenario

Since not all tasks are of the same difficulty, they cannot be graded in the same way, so the final score is calculated based on the remaining time and the sum difficulty level of each successfully completed task. The detailed game process is displayed in figure 5.

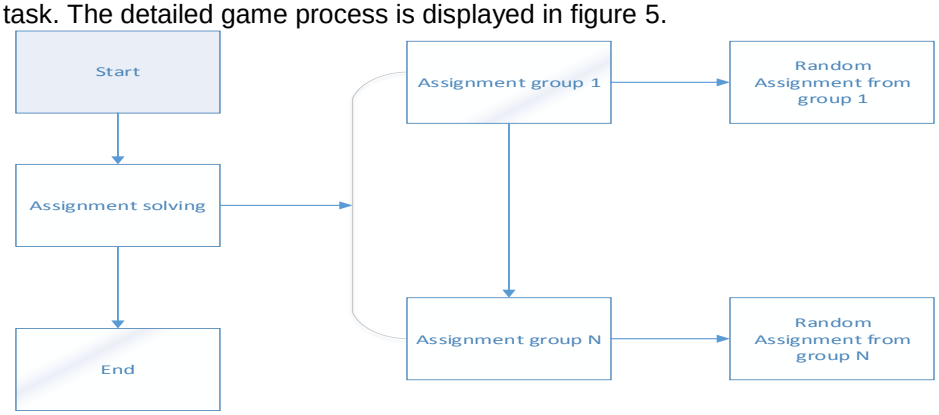

Figure 5: Task overview

Throughout the game, the student can review the solved assignments. After completion of all the assignments, or after the time has elapsed, the score that student achieved is calculated, shown to the student, and inserted into the administration application and Moodle.

An extra feature of the game is a hint option. Tasks are equipped with messages meant to point the student in the right direction in case there is trouble coming up with an answer. To use the help or not is up to the players themselves. Solving tasks awards grade points that make the final grade but there is another use for them. By collecting enough points a special button is made available. By pressing it students sacrifice points that have been used in the button but gain help on a complicated problem. Choosing this option lowers their final result but possibly awards another closed subject.

E. Assignments

A schema of an assignment is shown in figure 6. The displayed assignment is from the AR type. The student is required to scan the environment with the AR camera provided as part of the handheld device and recognize elements that are generated in the view. Based on his conclusions he reaches the answer and submits an answer.

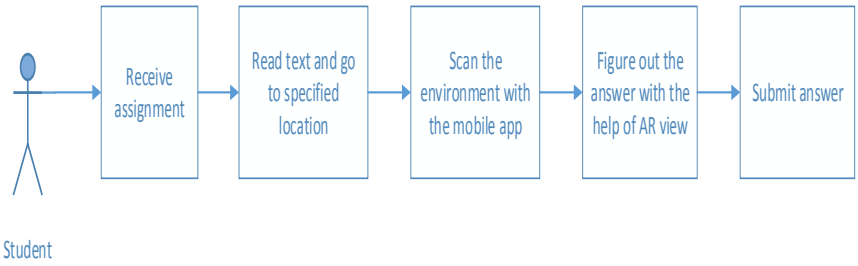

Figure 6: AR Assignment workflow schema

As an example, an AR assignment called Diagram completion will be presented. After arriving at the designated location, multiple pairs of IoT platform diagrams and QR codes will be present. A question can be seen on the first of multiple available screens of the mobile application and its text will tell the player how to activate the AR features of the game and that he needs to scan the diagrams and find the complete one. After reading the instructions and navigating to the AR screen players choose one of three available AR modes (see figure 7) and aim the camera at the first diagram and on-screen multiple 3D models of IoT elements will show up in different locations.

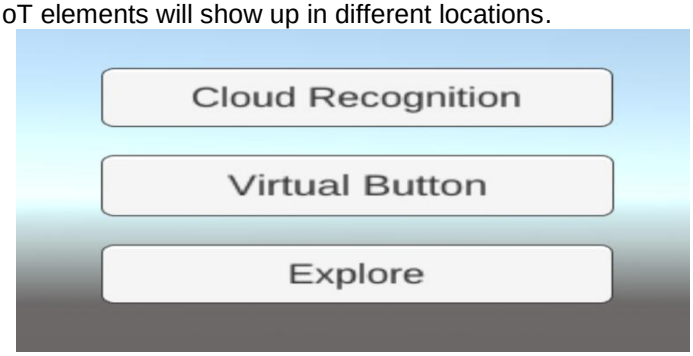

Figure 7: Vuforia module selection

Each diagram is missing at least one key component. Students need to find a diagram that when combined whose missing components are present in its 3D render. Such a combination of diagram and models is considered complete and is the correct one. Submission of the solution is done by navigating to the next application screen and pressing the button to scan the QR code paired with the previously selected diagram. QR tags hold codes for solving tasks. Tags paired with correct answers will match the assignment codes and mark the assignment as completed during check-up while all others will fail to match. Navigation through the application windows is done by swiping left and right on the device screen. Based on the task metadata, the mobile application will generate only the needed windows (figure 8). Generally, there are 3 windows present, the information window that holds the text of the question and necessary instructions as well as the location while the other two windows are dynamic and represent the widow for solving and the solution input window respectively. In the showcased example AR camera has been used for the former, while for the latter a QR code scanner was generated.

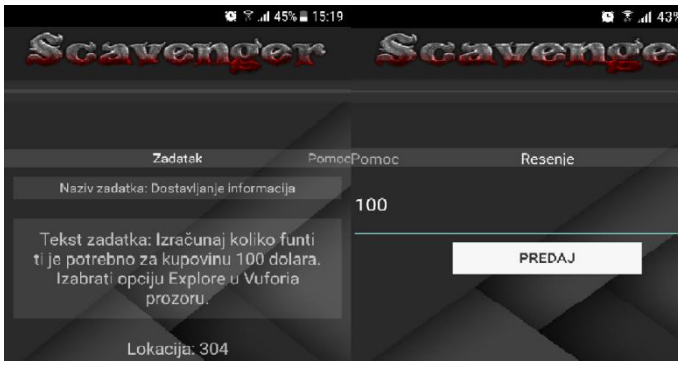

Figure 8: Task text and textual solution input

Another example of an AR task is named Model recognition. This task also tests the knowledge of the IoT models but is of lesser difficulty. The goal is to simply find the item that was specified in the text.

The process is the same as in the previously described example with small differences. Firstly there is only one diagram present on location, with a multitude of QR tags marked with numbers. After opening the AR window, 3 models will show up on screen, an IoT object and 2 buttons to change the center object. By using the primary model as number 1 and increasing the enumeration of every next model to the right of it by 1, or decreasing it by going left we can get the answer. We number models until we reach the required one and scan the QR code marked with that same number. In both examples, it is possible to look at the augmented reality from all sides and angles but it is also possible to rotate and scale models by interacting with the screen. This feature makes it easier to see details if necessary.

Figure 9: Vuforia task example

4. RESULTS

For the evaluation of the developed game, a pilot testing was organized at the Faculty of Organizational Sciences, University of Belgrade, within the Department of Electronic Commerce (e-lab) during the Summer School attended by undergraduate 4th-year students. The goal was to test the efficiency of using the developed game while learning about the Augmented Reality technologies. The research was conducted in accordance with the code of professional ethics. All students willingly agreed to contribute to this research.

The research involved 7 students who attended the Internet of things course. After using the application, students filled in a poll in which they gave their opinion on the way each task was solved. The questionnaire had 10 questions and the students could demonstrate their opinion on the offered five-step scale from "I completely agree" to "I completely disagree".

Each student received a mobile phone on which a mobile application was installed. Their tasks were to launch the application, log in to the Moodle system, and press the button in the displayed menu - launch the game. The system then selected one of the tasks randomly. If the student does not solve the exact task, they have the ability to re-test within a given time again. After the expiration of the time or after solving all the tasks, it was necessary to press the button "finish the game". Two of the offered tasks were Vuforia type.

The student had the task of reading the text on the screen of the mobile phone, then going to the assigned location from the task. Within the application, it was needed to move the screen to the right and click on the scan, then select the option specified in the text of the task and position the device so that the image is visible on the camera. The students needed to select a 3D model that matched the task's solution, double-click the "back" button, move the screen to the right and click on the scan. The device had to be positioned to see the QR code corresponding to the selected model. The last step was to move the application screen to the right, enter the read message into the displayed field, and click "Submit". Finally, students who participated in the research-filled in the questionnaire, answering questions about the application itself. In the given survey, students expressed their opinions on the application, but also answered questions that were related to satisfaction in solving each of the three questions asked.

A. Knowledge test results

The table shows the opinions of students related to the use of the extended reality application while solving the tasks set.

Regarding whether tasks were easier to solve by using the application, 71.43 percent of students said they fully agreed with the view that it was easier to solve the task with the application, while the other 28.57 percent of students replied that they could not decide.

No one answered that they partially or completely disagree that their tasks are easier to solve using the application.

Table 1: Questionnaire data

Question	% Strongly agree (score = 5)	% Agree (score = 4)	% Neutral (score = 3)	% Do not agree (score = 2)	% Strongly disagree (score = 1)	Mean score	Standard deviation
The task is easier to solve with using the application.	71.43	0.00	28.57	0.00	0.00	4.36	0.82
The task is easy to learn.	85.57	14.29	0.00	0.00	0.00	4.71	0.49
It's boring for me to solve this task like this.	14.29	14.29	28.57	14.29	28.57	2.64	1.29
I had the feeling of controlling the situation while solving the task.	42.86	57.14	0.00	0.00	0.00	4.36	0.54
Too bad that there were no more tasks of this type.	42.86	28.57	28.57	0.00	0.00	4.14	0.78
There was enough time to solve this task.	71.43	28.57	0.00	0.00	0.00	4.64	0.54
There was insufficient time to solve this task.	42.86	0.00	28.57	14.29	14.29	3.43	1.40
There was too much time to solve this task.	14.29	14.29	14.29	42.86	14.29	2.43	1.21
I prefer the classic test for solving this type of task.	14.29	14.29	14.29	28.57	28.57	2.43	1.33
The task is more fun to solve with the application	85.57	14.29	0.00	0.00	0.00	4.71	0.34

When asked if the tasks were easy to learn, 85.71 percent of students replied that they fully agreed, and one student partially agreed.

Students in a percentage of 85.71 percent agree that it is more fun for them to solve tasks using the application, and as much as 42.86 percent think it is a pity that there were no more tasks of this type. When asked if they have a sense of controlling events while solving tasks, 57.14 percent of students agree in part and 42.86 percent of students fully agree. Students' indecisiveness is evident over time in solving tasks. We see that 42.86 percent think that there was insufficient time to solve the tasks, while in the same percentage; the students think that there was too much time to solve the tasks. It is believed that this way of solving tasks for students is new and, depending on their readiness and skills in the use of new technologies, their position on this issue varies.

A certain number of students, 28.57 percent cannot decide and put their opinion in a large number of questions.

This means that although they agreed that the given application was useful, they were not convinced that it fits their needs.

B. Opinions about the application

After completing the coursework, students expressed their opinion on the most sensitive and most negative aspects of the application.
As the most positive aspects, they stated:

- Ease and simplicity,
- Interactivity,
- Interest,
- Facilitates learning and
- Virtualization.

According to the answers, the most negative aspects were:

- QR code is not being scanned,
- The application can crash,
- Slowness,
- Taking a lot of device storage space.

In the further stage of the research work, and the development of applications of expanded creativity for educational purposes, the answers of students who could not decide when it comes to needs and expectations, save time, easier tasks, in particular with the aim of improving the application as well as more successful and more efficient educational process.

5. CONCLUSION

The evaluation was conducted during practical lessons with undergraduate students in the course of the Internet of Things. Testing was done with a small group of students. The results showed that the application of augmented reality, used in conjunction with the game model, has the potential for implementation, that students considered it useful and fun, and that it contributes to their knowledge, as well as the quick and easy overcoming of the subject material. It also provided guidelines and suggestions for improving the application of augmented reality in widespread use in the educational process. In addition to improving the technical aspects of the system, the future work will be directed towards the development of a larger number of tasks, further integration with Moodle and complete technical and educational assessment of the system.

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DEVELOPMENT OF VIRTUAL SIMULATIONS FOR THE NEEDS OF MILITARY EDUCATION

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Abstract: *The analysis of contemporary systems for creating virtual simulations, difference between classical games and those supported by simulations, problems encountered by creators of scenarios, as well as the application of virtual simulations for the needs of military education are presented in this paper. The specific system for creating VBS3 virtual simulations shall be presented in the paper. Its comparing with commercial games has been done. Also, the advantages and disadvantages of these systems have been given. Its modular structure, as well as creating and using the user defined modules (script files) will be especially emphasized. The realization of the entire scenario with solving concrete problems will be discussed too. The end of the paper brings a brief description of the mode of system utilization, as well as the system evaluation, which is necessary for further implementation of this system in military training.*

Keywords*: virtual simulations, military education, VBS3, serious game, e-learning, edutainment*

1. INTRODUCTION

The Ministry of Defense and Serbian Army are trying to provide high-quality education and further advanced training for their members. Besides traditional education attention has been paid to electronic education and application of virtual simulations in the educational process.

During the last decades one of the biggest changes is an increasing use of computer games and virtual simulations (Hainey, Baxter, Boyle, Moreno-Ger, Connolly, 2013).For this reason, it is necessary to perceive the benefits of learning compared to playing games and whether this complies with the theory of learning (Lindgren, Schwartz, 2009). In this paper we will present the specific system for creating virtual simulationsVBS3. We will also present an evaluation of the proposed solution.

2. PRESENTATION OF VBS3 ARCHITECTURE AND DESIGN

Commercial games are primarily designed for entertainment. The value of applied or serious games is in the education and training (Minhua, Oikonomou, 2016). Playing games is not bad if they have been designed on the basis of simulations and when they contain educational value (Tobias, Fletcher, Wind, 2011). In this section we will explain the software use and classification of virtual simulations in the army environment.

The classification based on complexity, methodology being used and objects level have been generally accepted in computer simulations, as follows (Šimić, 2012):

- Live Simulations – real environment, soldiers or blank ammunition.
- Virtual Simulations – developed and designed by programmers or a team of experts in complex software environment.
- Constructive Simulations – the most complicated, designed for the training, as well as for the training of personnel and commanders of integrated tactical structures.

VBS3 (Virtual Battlespace 3) is interactive, commercial-off-the-shelf (COST – software which is on sale), 3D training system providing the environment for creating an enormous number of the spectra of simulations for military training, can also serve for research purposes. It is based on modern 3D gaming technology. The emergence of VBS3 brings improved performances and multicast system is introduced, which enables the adapting of participants to the multiplayer operating mode, prevents delays occurring at server loading, improves performances in the local network. The commanding and managing system has been super structured by the ORBAT mode enabling a hierarchy in commanding (VBS3 v3.2 User Guide, 2014).

VBS3 is a flexible, open-platform simulation software providing programmers a broad spectrum of possibilities in creating the training scenario. Open-platform enables the link of the external applications with the VBS through API (Application Programming Interface) module. The architecture of the VBS system is

shown in Figure 1, where its modular structure can be seen precisely. The system itself is in connection with the database with which it performs data exchange and registration.

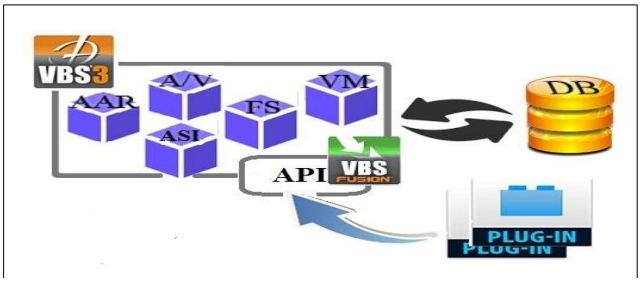

Figure 1: VBS Architecture

We shall demonstrate the differences between commercial games and virtual simulations on the example of the VBS software and one of the classics in the world of video games, Call of Duty (CoD). VBS brings the possibility of independent creating of the scenario. One of the essential characteristics of the VBS software is the possibility of analysis and evaluation of previously completed simulation exercise, while in the world of games this does not exist.

In addition to system defined there are also user defined modules represented by scripts (organized in the so-called sqf files) written in special VBS3 script language. Controls and data, written in the script, are converted into script files through the conversion module. Then, through conversion module, it is converted into the data type understandable to the user. When starting any scenario, the script file will be compiled each time. The number of user defined modules is not limited. Selecting other modules is carried out through initialized modules by using a special macro – controls execVM, call or preprocessFile. In the example, set forth in the paper, three user defined modules have been created in the scenario, the initializational and the module of synthetic units status (AI – Artificial intelligence) and real player control mode.

Starting of VBS3 can be carried out in two modules: user and administrator modules. Administrator module enables a complete access to audio, video and other advanced settings and has a complex interface. In the user mode the settings are very restricted, interface simplified, and RTE (Real Time Editor) is not available, because it is intended for simulation managing and control (VBS3 Manuals Version 17.1.0 , 2017).

3. PRESENTATION OF THE SCENARIO

The presented scenario is the research of the possibilities of training of the infantry squad in surmounting obstacles, coordination, management and commanding, as well as the implementation of the basic tactical training in the environment simulating reality. For the implementation of the scenario a terrain has been chosen, the geographical-topographical characteristics of which mostly corresponded to real characteristics the participants in the training can encounter. As far as time is concerned, the scenario can be divided in two parts: introductory and main part. In the introductory part of the scenario the participants have no control over their units, it serves to participants to be informed about the situation, concrete tasks, understand their roles in a team and that players who encountered such type of software for the first time get familiar with the controls serving for controlling the units. A special script has been made in the introductory part for creating and controlling objects, saved in a special file (blufor. sqf). The realization of the introductory part starts with creating two groups. The group located in the expectation region (Group B) and support groups (Group A). Figure 2 shows the view of the scenario map.

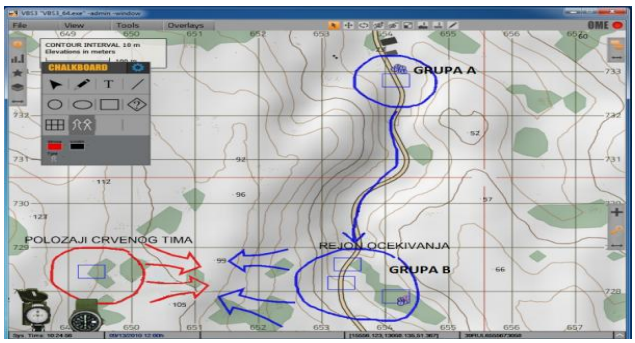

Figure 2: View of the scenario map

In the expectation region the task of Group B is to wait for the arrival of the support group. The central part of the introductory part is on Group A that should get on a combat vehicle and reach Group B in order that a squad is formed which would, from the expectation region, go in order to carry out tasks. After the arrival of Group A and forming of a squad, real participants take over control over their units and start performing the tasks. Practically, this is the transition phase in which human intelligence takes over partial control from the artificial intelligence. The main part of the scenario begins here, in which two tasks are carried out. The first task is destroying mine-explosive device (MED) located on a road, by means of a sniper rifle.The second task is occupying defined point on a map where fortified enemy forces are located. In the example, we created a mine-explosive device and a vehicle.

Practically, a trigger of defined type is created (empty detector), which is positioned on the corresponding coordinates on a map with determining the reaction zone. The function executed at its activation is in the last code line – in the concrete example, 5 soldiers are getting off a vehicle. From that moment players gain control over their units, and the text of the tasks, that a squad should perform, is written on the screen, and the titleText control is used for that. For creating enemy forces, a special module has been designed – script file opfor.sqf. For creating the units, the function createUnit is used. A unit can represent an individual soldier or their group. Furthermore, a unit can be controlled by participants, or by the VBS (AI Unit Control - Artificial Intelligence) and in that case, it is completely independent.

Besides creating units, it is necessary to adapt their conduct by using the control setCombatMode. There are five levels of training graded from the lowest to the highest, "blue", "green", "white", "yellow" and "red". Practically, it has been concluded, during the research, that for the enemy the level "white" is optimal for the confortation with the level of the participant of the simulation. The level "white" means that AI units will not open fire except in the case of an immediate danger and they will react defensively if attacked. Setting (adjusting) the level of training is performed individually for each unit, as presented in the paper, 7 enemy AI soldiers set on the "white" level. Combat mode "red" means the offensive responding of a unit – immediately after finding the enemy. This does not mean that the fire will be opened beyond weapon range, but the undertaken combat actions will be with the aim of destroying the enemy (concealed movement, taking cover, watching, aiming). Mode "yellow" enables a unit to attack the enemy if it is in the action zone, whereby units retain the disposition (formation). Mode "blue" means that units will never attack the enemy. From all stated, one can draw a conclusion concerning the "white" mode as the most convenient for the needs of unit training.

4. EVALUATION OF THE SUGGESTED SOLUTION

An increasing use of simulations and games in the education and training puts a question to us as to what do we gain by that, and what do we lose (Roman,Brown, 2008)?We get the answer by developing the methods forevaluation of the software on which education is performed, in order to perceive its possibilities, limitations, as well as the effect on learning (Hainey, Baxter, Boyle, Moreno-Ger, Connolly, 2013). The main idea in this section is to present our method for evaluation, by measuring time in different situations.

On the tactical level, in order to carry out the drill successfully, we must know the potentials of the units we have at disposal. The time required for a unit in the simulation to pass a defined distance depends on many factors, such as: terrain configuration, equipment carried, characteristics of a terrain, as well as on the endurance of units. Artificial intelligence, implemented in the VBS3 software, enables the control of these variables, their effect on the simulation, in order to approximate virtual behaviour to a real one as much as possible. Figure 3 shows the dependence of time on the way of movement and distance on a plain terrain. Measuring for movements has been performed: marching (normal walk), running and crawling. In the VBS3 this dependence is expressed by the fatigue variable. Fatigue is the least when walking (marching), while the greatest is when running.

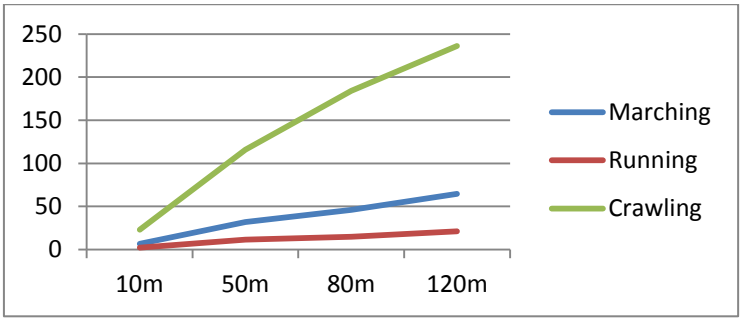

Figure 3: Movement of units on a plain terrain

Measuring has been also performed on a hill terrain. Results are shown on the following diagram (Figure 4), and based on them the effect of fatigue indicators on unit performances can be seen. As a section is increasing (becoming bigger), we can see the exponential increase in time, necessary to pass a section. A unit moving by running uphill has a drastic change of the fatigue indicator.

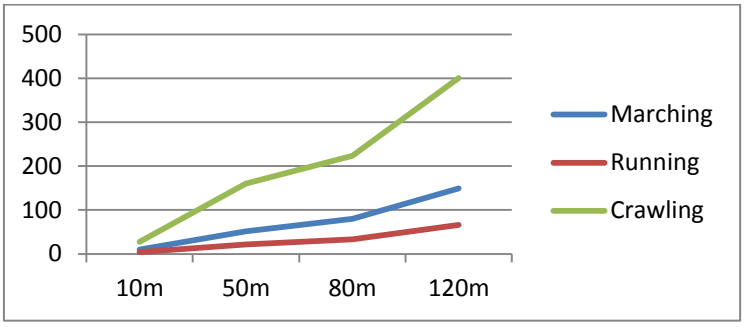

Figure 4: Movement of units on hill terrain

In addition to basic, there are also specific movements being modeled in the system. Table 1 shows the dependence of time for a crew, getting on a vehicle, on soldiers distance from a vehicle. The complete crew of a combat vehicle took part in measuring.

Table 1: Time of unit getting on a vehicle

	Directly in front of a vehicle	**10m**	**100m**
Time [sec.]	4,80	7,69	22,90

In the implementation of the scenario it is necessary to establish the time it takes AI units to react from different action zones to the participant (the so-called blue) team. This information is closely connected with the level of training of AI units. In high training states (red and yellow) the time that has passed from noticing a unit up to opening fire is very little and participants who are not trained sufficiently and have no experience in the use of software, have no chances against them. Downward trends for the blue and green level tells that on the distances of 250m, namely, 300m, AI units become completely passive relative to the enemy. Table 2 shows the time it takes, as from the moment of noticing, an average trained player to neutralize the enemy soldier on various distances. Comparing these data with the data for AI units, it is evident that the reaction of an average player is approximate to the ''white'' level of training.

Table 2: The time it takes a player to neutralize the enemy

	100m	**200m**	**250m**	**300m**
Time [sec.]	3,00	5,50	6,60	8,10

This means that either the participants' level of training should reach the level required for the given scenario (preparing for the drill – exercise), or when creating the scenario, one should realize the possibilities of change in the level of enemy training (AI units) in compliance with the current participants' level of training.

5. CONCLUSION

Efficient, modern and rational army presumes the employment of highly qualified and skilled personnel. Computer simulations enrich the educational process, stimulate the staff and train the personnel (Šimić, Gajić, Vukadinović, 2018).

The use of the VBS platform in research and education enables the experimentation with minimum costs of resources, improvement of education quality by better application for the training on the terrain (transition of theoretical to practical knowledge by transfer of experience from the virtual to real environment). As an argumentation, only a part of a typical military scenario is presented in the paper. However, virtual simulations have not exclusively a military purpose, but they can be also applied in the training for preventing and control of extraordinary events (state of emergency) and natural disasters, anti-terrorist combat, conversion, negotiating in various cultural environments and situations, protection and supervision of entry and exit from security susceptible areas and similarly. Also, an advantage is that conditions, not occurring at all or seldom in the real world, can be simulated.

The Military Academy, in addition to theoretical knowledge, also provides practical knowledge to attendees. We must not disregard the traditional form of education. The opinion of many people is that this form of education should remain the basic and enrich the educational process by means of contemporary

technologies (Dillenbourg, Fischer, 2007).E-education opens new prospects and privileges for all participants in the education. E-learning means the development of a new educational system. In the conditions of fast technological possibilities and changeable market conditions, the educational system should provide better educational opportunities without increasing financial resources. The Ministry of Defense and Serbian Army aim at responding to this challenge by the development of various e-learning programs, including the possibility of application of virtual simulations in the educational process.

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